Full Length Research Paper

Analysis of the business performance benchmarks

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Abstract

In facing the trend of globalization, the reform and revolution of the financial industry has forever changed the format of competition in Taiwan. This research suggests improvements to the slack variable based Context-Dependent DEA model proposed by Morita et al. (2005), and proposes the enhanced model with the Varying Returns to Scale hypothesis. The research takes samples from 33 banks in Taiwan, and analyzes them to suggest improvements for inefficient DMUs. Categories are proposed such that the DMUs are separated into different levels. This will assist banks in redefining their market positions and better understanding their opportunities and threats. Furthermore, the relative attractiveness and progressiveness of the banks are evaluated to find their respective benchmarks as a reference for improving their operational strategies.

Keywords: Benchmarks, business performance, Data Envelopment Analysis, efficiency.

INTRODUCTION

The economic development of a country heavily relies on a solid and comprehensive financial system. Therefore, the management of such a system has always been the center of people's attention. The Taiwanese government passed the Financial Institutions Merger Act and the Financial Holding Company Law after joining the World Trade Organization. These regulations helped financial institutions in Taiwan face up the fierce competition brought by competitors from abroad. These regulations encouraged financial institutions of the same nature to merge, and promoted the loosening of restrictions on mergers between companies in the same industry and cross-business operations. The changes were prompted by the hope that the adoption of diverse operations would allow banks to utilize economies of scales to the maximum extent and therefore increase their business performance and industry competitiveness. Very few studies have analyzed and discussed the benchmarks and industry positioning of the banking industry from an efficiency perspective. In order to better differentiate against and outperform competitors, such a topic must be discussed and reviewed in detail.

Andersen (1996) believes that benchmarking is a process whereby a company continuously measures itself against another company, and therefore allows the organization to gain recognition and information to help it improve its performance. The benchmarking strategy does not merely distinguish and measure to find which competitor in the industry performs best, it is a learning method that stimulates an organization to develop its own 'best practices model'. By finding its own best practices model, an organization can adjust it as appropriate and can use the adjusted model to help maximize its performance. Therefore, benchmarking should be regarded as a dynamic process. Anand and Kodali (2008) reviewed the benchmarking literature revealed that there are different types of benchmarking a plethora of benchmarking process models. A user may find it difficult when it becomes necessary to choose a best model from the available models. The first step in the benchmarking process is to identify a target with superior performance which will be set as a benchmark for the company. Benchmarking is a widely cited method to identify and adopt best-practices as a means to improve performance. Data envelopment analysis (DEA) has been demonstrated to be a powerful benchmarking

methodology for situations where multiple inputs and outputs need to be assessed to identify best-practices and improve productivity in organizations.

Some studies have identified financial performance as the key reason for benchmarking (Cassell et al., 2001; Maiga and Jacobs, 2004), but however, according to Anderson and McAdam(2004), focusing benchmarking on financial performance is backward looking and more predictive measures of performance need to be applied to benchmarking. In terms of measuring performance, the most widely used method applied in various industries is Data Envelopment Analysis (DEA). Formerly, academics have used the results from DEA to rank the performances of Decision Making Units (DMU), and those with lower rankings would naturally use the ones on top of the rank as their benchmarks. Tone (2001, 2002) proposed slack variables analysis, which provides inefficient DMUs with references to learn from and improve their performances. However, the concept of these two methods is both evolved around the best performing unit, and they do not discuss or analyze DMUs that display poorer efficiencies or inefficiencies. In order to provide more information, Seiford and Zhu (2003) and Morita et al. (2005) proposed the Context-Dependent DEA model. In this model, inefficient DMUs also play an important role in the evaluation process as they assist in finding other DMUs of the same level who display similar competitiveness.

In this paper, the discussion extends to the model proposed by Morita et al. (2005), where under varying returns to scale (VRS), all DMUs are grouped in an objective manner. Therefore, apart from identifying each DMU's market position, the relative attractiveness and progressiveness of DMUs in one level compared with that in another level are also calculated, and this method provides the basis for analyzing benchmarks. In other words, according to Spendolini's (1992) three types of benchmarking, namely internal benchmarking, competitive benchmarking and functional benchmarking, the Context-Dependent DEA model can segregate companies into different levels. Companies on the same level should adopt internal benchmarking, and companies on different levels should adopt competitive benchmarking in order to find the best learning path.

Due to the financial regulation, Taiwan's financial system had been protected in 1980's. After the 1980s, financial liberalization had gradually become a fashion in the international community, together with the expansion of exports, Taiwan government passively engaged in financial liberalization and gradually open up the domestic financial market. 1991 to 1992, the government approved the establishment of 16 new banks, and the trust and investment companies, large credit unions and SME banks restructuring of commercial banks, which resulting in doubling the number of commercial bankers. As financial institutions around the world became more internationalized and globalized, the trading activities of the financial industry continued to rise. The market structure was further complicated due to the diversity and innovativeness of products available. In 2001, Taiwan adopted the "Financial Holding Company Act" which brought a wave of consolidation. At the end of 2003, there were 50 domestic banks and SME Banks in Taiwan. Currently, There are 15 financial holding companies (of which 14 financial holding company under the Bank subsidiary), and 39 domestic banks in Taiwan. In this paper, we select the domestic commercial banks to remove incomplete information, the sample of 33 domestic commercial banks.

In facing the trend of globalization and the challenges brought by financial institutions abroad, Taiwan has irreversibly changed the format of competition in the financial industry. This change brings with it questions that business managers are particularly interested in, such as: 'What are the business performances of financial institutions like?', 'Who are the potential competitors within the industry?', and 'Who provide the benchmarks of business performance within the industry?'. Taking samples from the banking industry in Taiwan, this paper uses input and output data to determine the manner in which inefficient DMUs can improve their business performances. Furthermore, the market position of each bank is determined by grouping them into different levels (classes) to help them understand their respective competitiveness and weaknesses. At the same time, each bank's relative attractiveness and progressiveness are evaluated so their respective benchmarks can be identified, which serves as a good reference for improving their operational strategies.

Literature Review

DEA is a linear-programming-based methodology that has been demonstrated to be effective for certain types of benchmarking. DEA has been derived from the CCR model proposed by Charnes et al. (1978). Banker et al. (1984) proposed the BBC model that removes the restriction of having constant returns to scale as in the CCR model. Both the BCC or CCR model use linear programming to calculate efficiency values, and because they use a radial method to measure efficiency values, they are also called 'radial efficiencies'. Tone (2001) proposed a non-radial Slacks-Based Measure of efficiency (SBM) to evaluate efficiency values. The SBM model is more accurately and more effectively distinguish between efficient and inefficient DMUs. DEA allows one to compare organizations that use multiple inputs to produce multiple outputs and to measure these outputs and inputs in their natural units, i.e. without converting resources used and outputs into monetary units.Under the multiple-performance measure context, because it requires very few assumptions for its uses, DEA has opened up possilities for use in cases which were resistant to other benchmarking approaches because of

the complex nature of the relations between the multiple inputs and multiple outputs involved. Cooper et al. (2000) pointed that DEA has also been used to supply new insights into activities that have previously been evaluated by other methods.

In relation to using DEA to analyze the efficiency of businesses in the financial industry, academics had previously focused on topics such as technical efficiency, scale efficiency, or the comparison of performances before and after merger acquisitions. Very few have analyzed and discussed the benchmarks. Of the few academics who did discuss benchmarks, Roth and Jackson (1995), Soteriou and Stavrinides (1997), Manandhar and Tang (2002) used DEA to analyze and discuss the construction of a performance evaluation model for different branches within a bank and in turn discussed the topic of benchmarks. Donthu et al. (2005) expressed their opinions on the topic of benchmarking, and thought the concept lacked objective theoretical foundation. Therefore, they proposed the new concept of combining benchmarks and the DEA model. Sherman and Zhu (2006) applied quality-adjusted DEA to show that simply treating the quality measures as DEA output does not help in discriminating the oerformance. They report the results of applying quality-adjusted DEA to a U.S. bank's 200-branch network that required a method for benchmarking to help manage operating costs and service quality. Cook and Zhu (2010) introduced a new way of building perfprmance standards directly into the DEA structure when context-dependent activity matrixes exist for different classes of DMUs. Nigam et al. (2012) benchmarked the Indian mobile telecommunication service providers for relative efficiencies by DEA model. Wu et al. (2013) proposed a benchmarking framework with dynamic DEA approach to evaluate the efficiency and effectiveness of the hotel industry. However, using DEA to analyze and discuss benchmarks as mentioned poses certain issues. This is because traditionally, DEA works by firstly identifying the efficient DMUs on the frontier, and then using specific productive efficiencies as a basis for allocating each DMU a relative performance index. This implied that the traditional way of applying DEA to analyze benchmarks is the use of a reference set from the efficiency evaluation as subjects to learn from.

Seiford and Zhu (2003) used the BCC model from DEA as a basis for proposing the Context-Dependent DEA model. This model is the pioneer of the DEA model and groups DMUs of different efficiencies. Morita et al. (2005) proposed the Context-Dependent DEA based on the SBM model as an improvement. This model assumes constant returns to scale, but unfortunately only measures attractiveness and not progressiveness. Cheng et al. (2009) then expanded on the model Morita et al. (2005) proposed, adding the function of evaluating progressiveness and used tourist hotels in Taiwan as subjects for analysis. Chiu and Wu (2010) adopted the context-dependent DEA model to analysis

the operating efficiency of 49 international tourism hotel in Taiwan and to rank the values of attractiveness and progress. Compared with traditional DEA, the Context-Dependent DEA model is able to firstly rank all DMUs according to each respective level, and determine the best learning path for each DMU. This dynamic analytical method is of great sophistication.This paper develops the model proposed by Morita et al. (2005) to variable returns to scale and the relative attractiveness and progressivenesses are evaluated, which helps to identify potential threats posed by competitors.

METHODOLOGY

Seiford and Zhu (2003) used the BCC model from DEA as a basis to derive and propose the Context-Dependent DEA model. In this model, inefficient DMUs play a vital role in the evaluation process because apart from enabling researchers to better understand ways of improving inefficiency, they also help group DMUs into different levels (classes), which provides a clearer picture of where each DMU stands in its respective group.
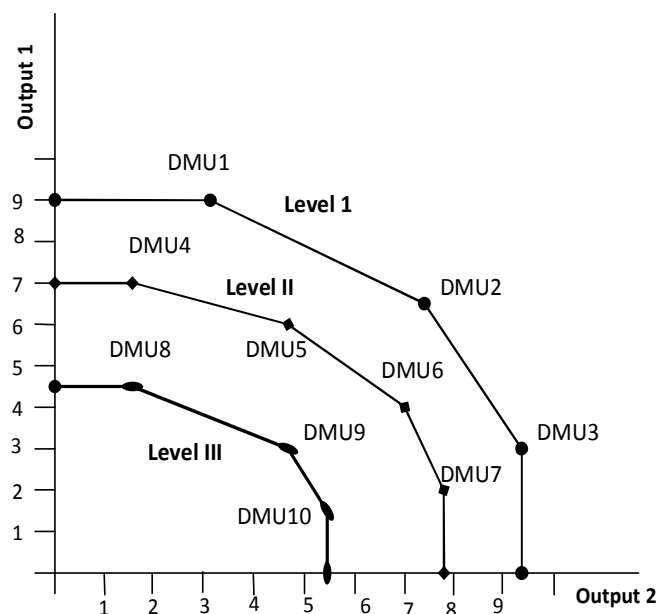
Figure 1. Context-Dependent DEA in the output-based model

Morita et al. (2005) followed the concept suggested by Seiford and Zhu (2003) and proposed the Context-Dependent DEA model based on the SMB model. In this model, the weaknesses of the BCC model are improved by using the SMB model to conduct efficiency evaluation and group the DMUs into different levels.

Unfortunately, this model assumes constant returns to scale and merely provides evaluation on attractiveness, but not progressiveness. Therefore, this research expands on this model to take into account variable returns to scale, and the improved model is called the Context-Dependent SBM.

1. **Context-Dependent SBM model – level designation**

Based on the SBM model, the Context-Dependent SBM model assumes there are n number of DMU, m inputs, s outputs, the input matrix $X = (x_{ij}) \in R^{m \times n}$, and the output matrix $Y = (y_{ij}) \in R^{s \times n}$. Therefore, under fixed returns to scale, the SBM model can be expressed as:

$$\min \quad \rho = \frac{1 - \frac{1}{m}\sum_{i=1}^{m} S_i^- \Big/ x_{i0}}{1 + \frac{1}{s}\sum_{i=1}^{s} S_i^+ \Big/ y_{i0}}$$

$$s.t. \quad x_0 = X\lambda + s^- \qquad\qquad (1)$$

$$y_0 = Y\lambda - s^+$$

$$\lambda \geq 0, s^- \geq 0, s^+ \geq 0$$

Multiplying the numerator and denominator in formula (1) by the same non-negative regular number t, making the denominator 1 and then solving the equation with the linear programming method, the model is expressed as follows:

$$\min \quad \tau = t - \frac{1}{m}\sum_{i=1}^{m} S_i^- \Big/ x_{i0}$$

$$s.t. \quad 1 = t + \frac{1}{s}\sum_{r=1}^{s} S_r^+ \Big/ y_{i0}$$

$$tx_0 = X\Lambda + S^- \qquad\qquad (2)$$

$$ty_0 = Y\Lambda - S^+$$

$$\Lambda \geq 0, S^- \geq 0, S^+ \geq 0, t > 0$$

In this equation, $S^- = ts^-$, $S^+ = ts^+$, and $\Lambda = t\lambda$. The best solution for (2) is $(\tau^*, t^*, \Lambda^*, S^{-*}, S^{+*})$. Therefore, the best solution for the SMB model is when $\rho^* = \tau^*$, $\lambda^* = \Lambda^*/t^*$, $s^{-*} = S^{-*}/t^*$, $s^{+*} = S^{+*}/t^*$. When the τ^* of any DMU (x_0, y_0) equals 1, the value is also the SBM efficiency. This means the DMU is not experiencing input excess or output shortfall.

The Context-Dependent SBM model proposed by

this research makes the assumption of variable returns to scale and it groups the samples into appropriate levels using objective input and output variables. The process of doing so is as follows:

1) Assume L=1 and evaluate all the DMUs together. Use the DEA model to find the first level with the efficient DMU set J^1, this gives us Level   and efficiency frontier E^1.

2) Delete all the efficient DMU sets identified in step 1) where $J^{L+1} = J^1 - E^1$. If $J^{L+1} = \phi$ then this process is stopped.

3) Use the DEA model to find the second level with the efficient DMU set J^2. This gives us Level II and efficiency frontier E^2.

4) Make $L = L+1$, return to step 2) and carry on the procedure up to this point.

5) Criteria for terminating the process: if $J^{L+1} = \phi$ then the process terminates, but the steps are repeated until all DMUs have their respective designated level or efficiency frontier.   Therefore the value 1 to L and L are determined by the stop criteria.   Finally, the values are compared based on different backgrounds and contexts.

Based on the criteria described above, the Context-Dependent SBM model with variable returns to scale can be expressed as:

$$\min \quad \tau_0^L = t - \frac{1}{m}\sum_{i=1}^{m} S_i^- \Big/ x_{i0}$$

$$s.t. \quad 1 = t + \frac{1}{s}\sum_{r=1}^{s} S_r^+ \Big/ y_{r0}$$

$$tx_{i0} = \sum_{j \in J^L} x_{ij}\Lambda_j + S_i^- \qquad i = 1,...,m \qquad (3)$$

$$ty_{r0} = \sum_{j \in J^L} y_{rj}\Lambda_j - S_r^+ \qquad r = 1,...,s$$

$$\sum_{j \in J^L} \left(\Lambda_j \Big/ t \right) = 1$$

$$\Lambda_j \geq 0, S_i^- \geq 0, S_r^+ \geq 0, \quad t > 0, \quad j \in J^L$$

In this equation, $s^- \in R^m$ input excess ; $S_i^- = ts_u^-$, $S_r^+ = ts_r^+$, and $\Lambda_j = t\lambda_j$. The best solution for (1) is $(\tau^*, t^*, \Lambda^*, S^{-*}, S^{+*})$ and therefore the best solution for the SBM model with variable returns to scale is when τ^*, $\lambda^* = \Lambda^*/t^*$, $s^{-*} = S^{-*}/t^*$, $s^{+*} = S^{+*}/t^*$. When $L = 1$, formula (1) is also the original SBM model with variable returns to scale.

2. Context-Dependent SBM - Attractiveness

The evaluation of attractiveness works by comparing efficient DMUs based on the result of inefficient DMUs. Tone (2002) developed the concept suggested by Andersen and Petersen (1993) and proposed the super-efficiency model with a slack-based measure of super-efficiency. This model excludes the DMUs to be evaluated from the reference set, and it takes the shortest distance between each DMU and the efficiency frontier as their respective super-efficiencies, where the super-efficiencies are ≥ 1. By applying this method on evaluating the attractiveness in the Context-Dependent SBM model, the efficient DMUs use inefficient DMUs as a reference. This means, the attractiveness relative to the DMUs in the next level category down are calculated by taking the shortest distance between the DMUs on the efficiency frontier in the level category above, and the efficiency frontier in the level category below it. The model for calculating attractiveness using the Context-Dependent SBM model is illustrated as follows:

$$\min \quad \delta_0^{(A)} = \frac{1}{m}\sum_{i=1}^{m}\left.\bar{x}_i\middle/ x_{i0}\right.$$

$$s.t. \quad 1 = \frac{1}{s}\sum_{r=1}^{s}\left.\bar{y}_r\middle/ y_{r0}\right.$$

$$\bar{x}_i \geq \sum_{j\in E^L, j\neq 0}\Lambda_j x_{ij} \qquad i=1,...,m$$

$$\bar{y}_r \leq \sum_{j\in E^L, j\neq 0}\Lambda_j y_{rj} \qquad r=1,...,s \tag{4}$$

$$\sum_{j\in E^L}\left(\Lambda_j\middle/ t\right)=1$$

$$\Lambda_j \geq 0, \quad t>0,$$

$$\bar{x}_i \geq tx_{i0}, \qquad 0\leq \bar{y}_r \leq ty_{r0,} \quad j\in E^L$$

3. Context-Dependent SBM - Progressiveness

The evaluation of progressiveness works in the opposite way to that of attractiveness, as it is calculated by comparing inefficient DMUs based on the result of efficient DMUs. The progressiveness values are the shortest distances between the DMUs on the efficiency frontier in the lower-level, and the efficiency frontier in the level above it.   The model for calculating progressiveness using the Context-Dependent SBM model is illustrated as follows:

$$\min \quad \varpi_0^{(P)} = \frac{1}{s}\sum_{r=1}^{s}\left.\bar{y}_r\middle/ y_{r0}\right.$$

$$s.t. \quad 1 = \frac{1}{m}\sum_{i=1}^{m}\left.\bar{x}_i\middle/ x_{i0}\right.$$

$$\bar{x}_i \leq \sum_{j\in E^L, j\neq 0}\Lambda_j x_{ij} \qquad i=1,...,m$$

$$\bar{y}_r \geq \sum_{j\in E^L, j\neq 0}\Lambda_j y_{rj} \qquad r=1,...,s \tag{5}$$

$$\sum_{j\in E^L}\left(\Lambda_j\middle/ t\right)=1$$

$$\Lambda_j \geq 0, \quad t>0,$$

$$0\leq \bar{x}_i \leq tx_{i0}, \qquad ty_{r0}\leq \bar{y}_r \quad j\in E^L$$

The Context-Dependent SBM model can effectively group DMUs into respective levels. Furthermore, it can evaluate the relative attractiveness of the DMUs and their progressivenesses. It provides a good basis for understanding each DMU's strengths and weaknesses, as well as distinguishing between close competitors and potential competitors.

EMPIRICAL RESULTS

The samples for this empirical research have been taken from 33 domestic commercial banks in Taiwan and the information extracted is the annual average data between the period of 2006 and 2008. The illustrations of the production process of banking are unclear in the reference articles. The definitions of the production process of banking can be found in the production approach and the intermediary approach.In the production approach, banks are considered tools utilizing capital, labor and facility to generate and provide deposits and loans (Berger et al., 1987; Parkan,1987; Farrier and Lovell,1990); on the other hand, intermediary approach considers that the functions of banks lie in providing the service of financial agents; that is, banks employ labors and invest resources in order to absorb savings and funds, also providing money to those who need it and transferring it to capital with interests. Furthermore, using the Intermediation Approach（ Berger and Humphrey, 1991; Siems, 1992; Yue, 1992; Hughes and Mester, 1993; Kaparakis et al., 1994; Yeh, 1996, three output variables and four input variables were included. Definitions of the information taken are recognized by intermediaries, where the input variables include the total capital, number of staff

Table1. Sample statistic

	Inputs			Outputs		
	number of staff (person)	Total capital (million NT dollars)	Total deposit l (million NT dollars)	Total loans l (million NT dollars)	Total Investment (million NT dollars)	service charge and commissions l (million NT dollars)
Mean	11,254	2,420,234	1,895,341	1,512,827	384,014,498	547,045
S.D	7,258	2,281,750	1,832,945	1,462,065	377,415,224	519,327
Max	26,250	9,279,711	7,671,811	5,365,433	1,198,599,430	1,947,903
Min	866	310,977	82,346	147,149	10,228,901	9241

Table 2. Results of level categorization in the Context-Dependent SBM

Level	Banks
Level I	Chang Hwa Commercial Bank, China Development Bank, Mega International Commercial Bank, King's Town Bank, Chinatrust Commercial Bank, Cathay United Bank, Bank of Kaohsiung, Industrial Bank of Taiwan, Hwatai Bank, Taiwan Cooperative Bank, Land Bank of Taiwan, Bank of Taiwan
Level II	First Commercial Bank, Hua Nan Commercial Bank, Taichung Bank, Taiwan Business Bank, E. Sun Commercial Bank, Taishin International Bank, Ta Chong Bank Ltd., EnTie Commercial Bank, Shin Kong Bank, The Shanghai Commercial and Savings Bank, COTA Commercial Bank, Bank of Pan Shin
Level III	Standard Chartered Bank, Taipei Fubon Commercial Bank Co., Ltd., Cosmos Bank Taiwan, Union Bank of Taiwan, Bank SinoPac, Yuanta Bank, Far Eastern International Bank, Sunny Bank, Jih Sun International Bank

and total deposit; the output variables include total loans, total investment, service charge and commissions. The sample statistics are as table 1.

1. Context-Dependent SBM – Level Categorization

The Context-Dependent SBM separates the 33 banks in Taiwan used in this research into three levels. Level I includes 12 banks which are the DMUs with the initial estimated efficiency value of 1. There are 12 banks included in Level II, and the 9 banks included in Level III. DMUs in the same level group display similar standards of performance and are organizations of the same business performance type in the market. Furthermore, banks in Level I are market leaders. The results from the level categorization exercise allow research samples to understand their own market position and their current business competitors, and therefore it helps them plan appropriate business strategies.

2. Context-Dependent SBM - attractiveness

In this paper, the values representing attractiveness and progressiveness are calculated by the Context-Dependent SBM model and the results are shown in Table 3. In the table, to the right of the diagonal line are the attractiveness values. The values representing attractiveness are the shortest distances

between the DMUs on the efficiency frontier in the level above, and the efficiency frontier in the level below it. Higher values means stronger attractiveness, in which the distance from the DMU to the frontier in the level category below is farther suggesting that the DMU is leading by a large amount in terms of attractiveness. On the other hand, the smaller the attractiveness values, the shorter the distances between the DMU and the frontier in the next level below, and in this situation the DMU in question must be aware of threats posed by potential competitors. Based on this principle, the DMUs are ranked in order of attractiveness, and the stronger the attractiveness, the better will be the ranking, and vice versa. By ranking them by attractiveness, the performance of DMUs within the same level category can be effectively compared.

Out of the banks in Level I and Level II, China Development Bank displays the strongest attractiveness, followed by the Industrial Bank of Taiwan. Both of these banks' attractiveness values are larger than 3, which means they are farthest from the level below. Bank of Taiwan ranks third with the attractiveness value of 1.4707. These banks are the top three banks in terms of efficiency and they lead the business performance of the market. At the opposite end of this level category, the King's Town Bank, Chang Hwa Commercial Bank, Chinatrust Commercial Bank are   the smallest attractiveness values in   this   level
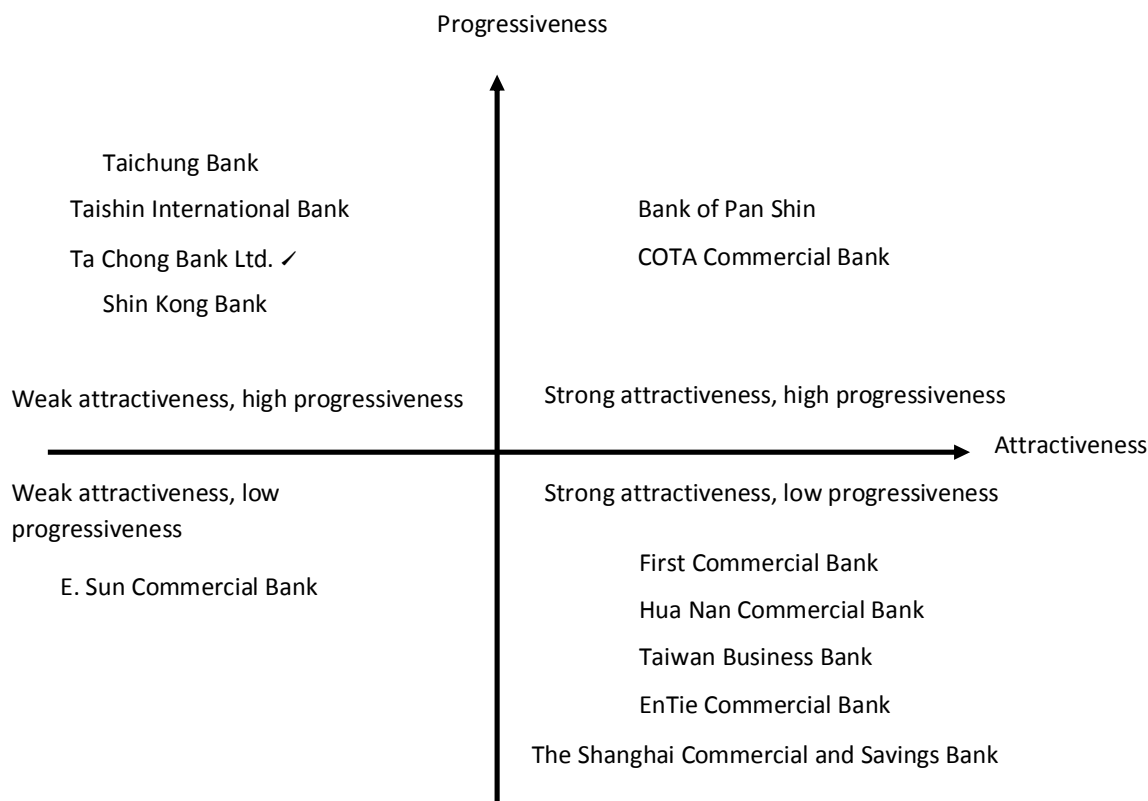
Table 3. Attractiveness and progressiveness calculated by the Context-Dependent SBM

Level category	Name of bank	Corresponding level		
		I	II	III
I	Chang Hwa Commercial Bank		1.0538289 (11)	1.4622995 (10)
	China Development Bank		3.2488681 (1)	5.6864023 (2)
	Mega International Commercial Bank		1.2362993 (6)	1.8230121 (6)
	King's Town Bank		1.0371789 (12)	1.3796719 (12)
	Chinatrust Commercial Bank		1.1020499 (10)	1.5666698 (9)
	Cathay United Bank		1.1096422 (9)	1.4021373 (11)
	Bank of Kaohsiung		1.1965233 (7)	1.9300341 (5)
	Industrial Bank of Taiwan		3.236796 (2)	5.7742829 (1)
	Hwatai Bank		1.115103 (8)	2.2190993 (4)
	Taiwan Cooperative Bank		1.3340094 (4)	1.7087402 (8)
	Land Bank of Taiwan		1.2893785 (5)	1.7976848 (7)
	Bank of Taiwan		1.4706778 (3)	2.6351633 (3)
Average value			1.535862942	2.448766458
II	First Commercial Bank	1.0097442 (3)		1.7653251 (2)
	Hua NanCommercial Bank	1.0097603 (4)		1.7276807 (3)
	Taichung Bank	1.147885 (9)		1.0776732 (7)
	Taiwan Business Bank	1.0018846 (2)		1.1809479 (6)
	E. Sun Commercial Bank	1.000205 (1)		1.0574011 (8)
	Taishin International Bank	1.2141978 (11)		1.0367178 (9)
	Ta Chong Bank Ltd.	1.1493846 (10)		1.0195982 (11)
	EnTie Commercial Bank	1.0428321 (5)		1.1750792 (6)
	Shin Kong Bank	1.13416 (8)		1.019929 (10)
	The Shanghai Commercial and Savings Bank	1.0827552 (6)		1.3557783 (5)
	COTA Commercial Bank	1.1011814 (7)		2.0186361 (1)
	Bank of Pan Shin	6.4295432 (12)		1.3681713 (4)
Average value		1.526961117		1.369073867
III	Standard Chartered Bank	1.1600522 (7)	1.0419044 (7)	
	Taipei Fubon Commercial Bank Co., Ltd.	1.1392581 (5)	1.036973 (6)	
	Cosmos Bank, Taiwan	1.4082307 (9)	1.2335935 (9)	
	Union Bank of Taiwan	1.2275089 (8)	1.1136529 (8)	
	Bank SinoPac	1.037413 (1)	1.0063737 (2)	
	Yuanta Bank	1.0893019 (2)	1.0000001 (1)	
	Far Eastern International Bank	1.0907824 (3)	1.0070802 (3)	
	Sunny Bank	1.1402497 (6)	1.0244509 (5)	
	Jih Sun International Bank	1.1257616 (4)	1.0179897 (4)	
Average value		1.15761761	1.0535576	

category, which means they must be aware of threats from potential competitors.

In terms of Level I attractiveness for DMUs on Level III, Industrial Bank of Taiwan displays the strongest attractiveness, followed by China Development Bank. Both banks have attractiveness values larger than 5, which mean the distance to the level below is very far suggesting that these banks have absolute competitiveness. In third place is Bank of Taiwan with the attractiveness value of 2.6351. Remaining on Level I, the bank with the weakest attractiveness out of the Level III banks is King's Town Bank, followed by Cathay United Bank, and Chang Hwa Commercial Bank. These three banks are relatively close to the level below, which means they must be aware of threats from potential competitors.

Progressiveness

Taichung Bank

Taishin International Bank

Ta Chong Bank Ltd. ✓

Shin Kong Bank

Bank of Pan Shin

COTA Commercial Bank

Weak attractiveness, high progressiveness

Strong attractiveness, high progressiveness

Attractiveness

Weak attractiveness, low progressiveness

E. Sun Commercial Bank

Strong attractiveness, low progressiveness

First Commercial Bank

Hua Nan Commercial Bank

Taiwan Business Bank

EnTie Commercial Bank

The Shanghai Commercial and Savings Bank

Figure 2.   Analysis of attractiveness and progressiveness within the Level II category

In terms of Level II attractiveness for DMUs on Level III, COTA Commercial Bank displays the strongest attractiveness, followed by First Commercial Bank and Hua Nan Commercial Bank. At the opposite end of this level category, the banks that has the weakest attractiveness is Ta Chong Bank Ltd with the attractiveness value of 1.0195, followed by Shin Kong Bank and Taishin International Bank.

In the Context-Dependent SBM model, the attractiveness of the DMUs in the level category above for those in the level category below should display an increasing trend.   From the empirical results, this characteristic is proved, with the average attractiveness value of Level I for Level II being 1.5358, the average attractiveness value of Level I for Level III being 2.4487, and the average attractiveness value of Level II for Level III being 1.3690.

3. Context-Dependent SBM- progressiveness

In Table 3, to the left of the diagonal line are the progressiveness values. Progressiveness values are based on the distance from the DMU in the level below to the next level up, the smaller the value means there is less room for improvement and that they are close to the next level up. In this case, the DMU is only lacking behind by a small amount and has a good chance of moving up into the next level category, and is regarded as a potential competitor for DMUs in the level category above it. On the other hand, the bigger the progressiveness value, the farther the DMU is to the next level category above and the more it lacks behind in terms of performance. Therefore, it poses little threat to those in the level category above.

In terms of the progressiveness of DMUs on Level II toward those on Level I, E. Sun Commercial Bank displays the smallest progressiveness value of 1.0002 approximately, which means it is closest to the level category above and is a potential competitor for DMUs in Level I. After E. Sun Commercial Bank, the banks ranked in progressiveness in order are Bank of Taiwan, First Commercial Bank, Hua Nan Commercial Bank, EnTie Commercial Bank, and The Shanghai Commercial and Savings Bank. These banks all have progressiveness values smaller than 1.1, which means they are potential competitors to those DMUS in the level category above because their distances to Level I are very short. On the other hand, the bank with the biggest progressiveness value on this level is Bank of Pan Shin. Its progressive value is 6.4295, and as such does not pose much threat to DMUs on Level I because it is very much lacking behind with the worst ranking in terms of progressiveness. Second to last is Taishin International Bank, with the progressive   value   1.2141,

followed by Ta Chong Bank Ltd., with the progressive value 1.1493. Whilst these two banks rank second and third last in terms of progressiveness, as the values are relatively small they still pose a certain amount of threat to DMUs on Level I.

In terms of progressiveness of DMUs on Level III toward those on Level II, in first place is Yuanta Bank, with the progressiveness value of 1. This means it is very close to the next level up and can almost be regarded as a DMU on Level II. The ranking of other banks in this category is as follows: Bank SinoPac, Far Eastern International Bank, Jih Sun International Bank, Sunny Bank, Taipei Fubon Commercial Bank Co., Ltd., and Standard Chartered Bank. These banks all have progressiveness values smaller than 1.1 so they are also close to Level II and are potential competitors to DMUs on Level II. At the other end of the spectrum, the bank that is lacking behind the most in this category is Cosmos Bank, Taiwan, with the progressive value of 1.2335. It ranks last in terms of progressiveness and thus is not considered much of a threat by other DMUs on Level II. The other banks at the end of the rank for this level are Union Bank of Taiwan, Standard Chartered Bank, Taipei Fubon Commercial Bank Co., Ltd., Sunny Bank, and Jih Sun International Bank. They all display progressiveness values smaller than 1.1 and thus are still considered as threats to DMUs on Level II.

In terms of progressiveness of DMUs on Level III toward those on Level I, Bank SinoPac is in first place with the smallest progressiveness value of 1.0374. It is therefore the DMU on Level III closest to Level I. In second place is Yuanta Bank and in third place is Far Eastern International Bank. Both these banks have progressiveness values smaller than 1.1, which means they are very close to Level I and are potential competitors to DMUs on that level. On the other hand, the bank with the highest progressiveness value on this level is Cosmos Bank, Taiwan, with the value being 1.4082. The second last bank is Union Bank of Taiwan with the progressiveness value of 1.2275, followed by Standard Chartered Bank with the progressiveness value of 1.1600.

4. Analysis of Strategies

One of the functions of the Context-Dependent SBM model is to categorize the samples into different level categories. In this research, the empirical results segment the samples into three level categories in order to identify their individual market positions. DMUs in the Level I category are the best-performing group, and DMUs in the Level III category are the worst-performing group. Therefore, banks on Level III should learn from those on Level II and gradually improve their business performances.

Secondly, the Context-Dependent SBM model can separate the DMUs into four different categories

depending on their attractiveness and progressiveness rankings, and DMUs in different categories should adopt different business strategies. DMUs with strong attractiveness are leaders in terms of performance and have no competitors. DMUs with small progressiveness values are potential competitors to those on the level above. Therefore, the DMU with the largest attractiveness value and the smallest progressiveness value will be the best-performing unit. On the other hand, DMUs with weak attractiveness have little competitiveness in terms of efficiency, so they must pay particular attention to potential competitors. High progressiveness, on the other hand, means the DMU poses little threat to the competitor on the level above. Therefore, the DMU with the smallest attractiveness value and the largest progressiveness value is the worst-performing unit. The principle was applied to help categorize banks on Level II into the four categories in accordance with their performance in terms of attractiveness and progressiveness. As shown in Figure 2, banks with strong attractiveness and low progressiveness include First Commercial Bank, Hua Nan Commercial Bank, Taiwan Business Bank, EnTie Commercial Bank, and The Shanghai Commercial and Savings Bank. These banks must utilize their competitive advantages and strive to move up the ladder by learning from banks in the level category above. Banks who display the characteristic of weak attractiveness and high progressiveness include Taichung Bank, Taishin International Bank, Ta Chong Bank Ltd., and Shin Kong Bank. It is more difficult for these banks to progress to the next level and they face threats from potential competitors. Therefore, it is advised that they remain highly alert to the business strategies adopted by competitors in the market so as to take appropriate actions in response. COTA Commercial Bank and Bank of Pan Shin have strong attractiveness and high progressiveness, which means it is difficult for them to progress to the next level, although they are still more competitive than those in the level category below and thus it is suitable for them to adopt a steady growth strategy. Finally, in the last category is E. Sun Commercial Bank, which has weak attractiveness and low progressiveness. This means it faces considerable threat from competitors in the level category below. Therefore, it should strive to progress to the next level by learning from banks on the level above.

Thirdly, the Context-Dependent SBM is able to distinguish between attractiveness and progressiveness within efficiency ranking. In the Level I category, DMUs with stronger attractiveness are farther from those in the Level II category and therefore display better performances and efficiencies. The level of attractiveness can therefore be used to rank the banks in the Level I category in terms of efficiency. In the Level III category, the smaller the progressiveness value, the closer the DMU is to Level II. Therefore, the level of

Table 4. Reference set of each level category

Name of bank	Level	Reference set of each level category	
		I	II
First Commercial Bank	II	China Development Bank, Chinatrust Commercial Bank, Hwatai Bank, Bank of Taiwan	
Hua Nan Commercial Bank	II	King's Town Bank, Chinatrust Commercial Bank, Taiwan Cooperative Bank, Bank of Taiwan	
Taichung Bank	II	King's Town Bank, Taiwan Cooperative Bank	
Taiwan Business Bank	II	King's Town Bank, Chinatrust Commercial Bank, Taiwan Cooperative Bank, Bank of Taiwan	
E. Sun Commercial Bank	II	Chinatrust Commercial Bank, Hwatai Bank, Taiwan Cooperative Bank, Bank of Taiwan	
Taishin International Bank	II	King's Town Bank, Chinatrust Commercial Bank, Taiwan Cooperative Bank	
Ta Chong Bank Ltd.	II	King's Town Bank, Chinatrust Commercial Bank, Taiwan Cooperative Bank	
EnTie Commercial Bank	II	King's Town Bank, Chinatrust Commercial Bank, Hwatai Bank, Taiwan Cooperative Bank, Bank of Taiwan	
Shin Kong Bank	II	King's Town Bank, Chinatrust Commercial Bank, Taiwan Cooperative Bank	
Shanghai Commercial and Savings Bank	II	China Development Bank, Chinatrust Commercial Bank, Cathay United Bank, Bank of Kaohsiung, Bank of Taiwan	
COTA Commercial Bank	II	Chinatrust Commercial Bank, Hwatai Bank	
Bank of Pan Shin	II	Hwatai Bank, Taiwan Cooperative Bank	
Standard Chartered Bank	III	King's Town Bank, Chinatrust Commercial Bank, Hwatai Bank	Taishin International Bank, COTA Commercial Bank, Bank of Pan Shin
Taipei Fubon Commercial Bank Co., Ltd.	III	King's Town Bank, Chinatrust Commercial Bank, Taiwan Cooperative Bank	Hua Nan Commercial Bank, Taiwan Business Bank, Taishin International Bank
Cosmos Bank	III	King's Town Bank, Taiwan Cooperative Bank	Taishin International Bank, COTA Commercial Bank, Bank of Pan Shin
Union Bank of Taiwan	III	King's Town Bank, Chinatrust Commercial Bank, Hwatai Bank	Taishin International Bank, COTA Commercial Bank, Bank of Pan Shin
Bank SinoPac	III	King's Town Bank, Chinatrust Commercial Bank, Taiwan Cooperative Bank, Bank of Taiwan	Hua Nan Commercial Bank, Taishin International Bank, The Shanghai Commercial and Savings Bank, Bank of Pan Shin
Yuanta Bank	III	King's Town Bank, Chinatrust Commercial Bank, Taiwan Cooperative Bank	Taishin International Bank, Bank of Pan Shin
Far Eastern International Bank	III	King's Town Bank, Chinatrust Commercial Bank, Taiwan Cooperative Bank	Taishin International Bank, The Shanghai Commercial and Savings Bank, COTA Commercial Bank, Bank of Pan Shin
Sunny Bank	III	King's Town Bank, Chinatrust Commercial Bank, Taiwan Cooperative Bank	Taishin International Bank, COTA Commercial Bank, Bank of Pan Shin
Jih Sun International Bank	III	King's Town Bank, Chinatrust Commercial Bank, Bank of Taiwan	Taichung Bank, Taishin International Bank, The Shanghai Commercial and Savings Bank, COTA Commercial Bank, Bank of Pan Shin

progressiveness can be used to rank the banks in the Level III category in terms of efficiency. As for Level II, both attractiveness and progressiveness are taken into account. There are three sub-categories within, with the first sub-category being DMUs with strong attractiveness and low progressiveness. Banks which fit this description are First Commercial Bank, Hua Nan Commercial Bank, Taiwan Business Bank, EnTie Commercial Bank, and The Shanghai Commercial and Savings Bank, in terms of ranking order. DMUs with strong attractiveness and low progressiveness include COTA Commercial Bank and Bank of Pan Shin, in terms of ranking order. E. Sun Commercial Bank falls into the category of DMUs with weak attractiveness but low progressiveness. Finally, the category of DMUs with weak attractiveness and high progressiveness include

Taichung Bank, Taishin International Bank, Shin Kong Bank, and Ta Chong Bank Ltd, in terms of ranking order. To summarize the above analysis, samples in this research are given an overall ranking, which is shown in Table 3.

5. Constructing the Analysis of Benchmarks

Under the level category structure in the Context-Dependent SBM, underperforming DMUs can learn from the reference set in the level category above, and the most suitable benchmarks can be identified by using the attractiveness values. The reference set of each level is shown is Table 4. Put simply, banks within the Level II category should learn from the reference set of Level I. Taking First Commercial Bank from the Level II category as example, the reference set it can consider has four banks within, including China Development Bank, Chinatrust Commercial Bank, Hwatai Bank, and Bank of Taiwan. By comparing the attractiveness of these four banks for Level II, it is evident that China Development Bank has the highest attractiveness value and Chinatrust Commercial Bank has the lowest attractiveness value. Therefore, First Commercial Bank should use China Development Bank as a benchmark. However, if the intention is to progress to the next level up, the Chinatrust Commercial Bank is probably a more feasible benchmark. Using another example, taking Standard Chartered Bank in the Level III category, the corresponding reference set in the Level II category includes Taishin International Bank, COTA Commercial Bank, and Bank of Pan Shin. By comparing the attractiveness of these three banks for DMUs in the Level III category, it is evident that COTA Commercial Bank has the highest attractiveness value. Therefore, it is the choice of benchmark out of the three banks in the Level II category. The other reference set Standard Chartered Bank can consider is that in the Level I category, and includes King's Town Bank, Chinatrust Commercial Bank, and Hwatai Bank. By comparing the attractiveness of these three banks for DMUs in the Level III category, it is evident that Hwatai Bank has the highest attractiveness value, so for Standard Chartered Bank, it is the benchmark choice out of the three banks in the Level I category. The benchmarking path for Standard Chartered Bank should therefore firstly use COTA Commercial Bank in the Level II category, and then move onto using Hwatai Bank in the Level I category as its benchmark.

CONCLUSION

Based on the model proposed by Morita et al. (2005), this paper proposes the Context-Dependent DEA model that solves problems traditional models have, such as the inability to evaluate and measure certain aspects. The newly proposed model also removes the assumption of constant returns to scale. In terms of empirical evidence, this research uses 33 banks in Taiwan as samples, and objectively categorizes the DMUs with the assumption of variable returns to scale. This process has helped identify the market position of each DMU, and as a result, assists organizations within the same category to adopt internal benchmarking. Furthermore, the Context-Dependent DEA model has been developed further to calculate the relative attractiveness and progressiveness of DMUs in each level category compared with those in another level category. This process provides the basis for the analysis of benchmarks across different levels, such that the best learning path can be identified. The summary of the empirical results is as below.

Firstly, the Context-Dependent SBM model groups the test samples into three level categories, which represent the three types of organizations defined by their performances. DMUs in the Level   category are the best-performing group with high efficiencies, and DMUs in the Level III category is the worst-performing group with low efficiencies. This system enables every bank in the sample to understand their current market position and business performance. Therefore, it assists them in planning business objectives and strategies. Secondly, the Context-Dependent SBM model calculates the attractiveness values and progressiveness values. The higher the attractiveness value, the farther the distance between the DMU and the next level down, implying that the DMU is a leader in this group. Alternatively, the smaller the progressiveness value, the closer the distance between the DMU and the level above, suggesting this DMU is a potential competitor for DMUs in the level category above. Therefore, by the use of attractiveness values and progressiveness values, each DMU can determine the level of threat they pose to other competitors and vice versa, helping DMUs understand the opportunities and threats they face. Thirdly, the Context-Dependent SBM model can separate the DMUs into four different categories depending on their attractiveness and progressiveness rankings, allowing DMUs in different categories to adopt different business strategies. DMUs with high attractiveness values and small progressiveness values should strive to progress to the level category above it. DMUs with low attractiveness values and high progressiveness values will find it relatively hard to move up to the next level as they also face threats from potential competitors. They should therefore remain particularly alert and be ready to respond to competitors' actions. DMUs that display strong attractiveness and high progressiveness should seek stable growth and development. Finally, DMUs with weak attractiveness and low progressiveness face threats from competitors in the level category below it. Therefore, they should work towards moving up to the next level. Fourthly, the Context-Dependent SBM model is able to rank the efficiencies of DMUs by taking into

account their respective attractiveness and progressiveness. Finally, under the level category structure in the Context-Dependent SBM model, underperforming DMUs can learn from the reference set in the level category above, and the most suitable benchmarks can be identified by using the attractiveness values.

Using the Context-Dependent SBM model, this paper discusses the market positions of various banks in Taiwan, their business strategies, and analyzes the benchmarks. The goal of this research paper is to provide an evaluation method to help improve resources for the banking industry in Taiwan and help provide a good reference for adjusting their strategies.

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