



A STUDY ON THE FINANCIAL OPERATION AND SUSTAINABILITY EFFICIENCY OF THE TAIWAN BANKING INDUSTRY - TWO-STAGE DDF

Hsu, Shao-Yin

Department of Accounting, Ming Chuan University
guday0323@gmail.com

Abstract

This study is prepared with a total of 37 banks in Taiwan in 2022-2024 as the research sample and with a two-stage dynamic directional distance function (DN-DDF) adopted. In addition to adopting parallel analysis of financial and operational efficiency in stage 1, the sustainability efficiency analysis is adopted in stage 2. The DN-DDF method is adopted in this study to overcome the limitations of static models.

In terms of overall efficiency, the ranked top three banks include CTBC, CLB and KTB, which are long-established banks in Taiwan. The ranked last three banks include DBSB, NCB, and RICB, which have experienced financial crises and been acquired and merged, or are newly established online banks; however, online banks have performed well in the sustainability stage. In addition, the so-called state-owned banks, including TCB (ranked 21st), BOT (ranked 20th), LBOT (ranked 24th), and CHB (ranked 26th), all ranked in the lower half of the overall efficiency classification, and performed poorly in the stage of sustainability efficiency. State-owned banks should pay more attention to ESG. Overall, the efficiency performance in Stage 1 and Stage 2 is good, but not in the sustainability stage, which is yet to be improved.

Keywords: DDF, bank, efficiency, ESG

Introduction

Taiwan's financial and insurance industry accounted for approximately 6.41% of GDP in 2025. The financial industry provides corporate financing, financial transactions, settlement services, and asset management; therefore, it is very important to national economic development. Scholars have pointed out that the banking industry plays an important role in national economic development worldwide and influences national economies. Bank operators must improve efficiency and profitability; also, mitigate risks to drive national economic growth (Luo et al., 2016; Batten et al., 2019; Pham et al., 2024).

The banking industry faces multiple challenges due to the fierce competition in the global financial market, including rising operating costs, complicated risk management, and constantly changing customer needs. Global banks may differ in their capital investment strategies and market characteristics; however, their capacity for risk mitigation remains equally significant. Enterprises worldwide faced various crises during the outbreak of the COVID-19 pandemic in 2020, including increasing default risk faced by the banking industry (Amirteimoori et al., 2024) and a sharp

decline in profits due to banks adopting conservative lending strategies. Therefore, improving profitability is essential for banks to enhance their resilience and recovery capabilities in a difficult situation.

In addition, global climate change has resulted in a severe challenge to agriculture and water resources; therefore, all industries have started to appreciate the importance of environmental issues. Enterprises pursuing sustainable development must strike a balance between commercial interests and environmental protection. Nevertheless, the advancement of sustainable development is contingent upon financial resources, which are dependent on the financing services provided by banking institutions. Banks must integrate financial resources to guide enterprises in implementing environmental protection, social responsibility, and governance. Therefore, the banking industry must first implement ESG (Environment, Social, Governance) policies itself and set an example for enterprises in fulfilling environmental protection and social sustainability responsibilities.

This study utilizes a research sample comprising 37 banks in Taiwan during 2022-2024 and employs a two-stage

dynamic directional distance function (DN-DDF). In addition to conducting parallel analyses of financial and operational efficiency, a sustainability efficiency analysis is performed in stage 2.

The Dynamic Directional Distance Function (DN-DDF) has been employed in this study to surpass the limitations inherent in static models, to enhance the assessment of corporate financial and operational risks and efficiencies, and to more accurately depict real-world policy dynamics, aiming to offer precise and practical insights for banks in policy formulation. The findings of this study are intended to serve as a reference for industry stakeholders, government agencies, and investors in their decision-making processes and investment strategies.

Literature Review

The relevant banking literature is introduced as follows. Research shows that higher bank capital correlates with better management and increased profitability; thus, raising capital enhances financial stability (Saleh et al., 2020). Other findings suggest that economic growth drives banks to expand lending and deposits (Petria et al., 2015). Influential factors to bank profitability

include size, debt-to-asset ratio, deposit-to-asset ratio, equity-to-asset ratio, debt-to-equity ratio, and loan-to-deposit ratio (Yuan et al., 2022). Additionally, a study on how bank capital affects profitability reveals an inverse relationship between bank risk and ROAA and ROAE, as higher funding gaps or liquidity levels can reduce banks' profitability (Saleh and Afifa, 2020).

Research on bank ESG include: Houston and Shan (2022), they found that banks were more likely to lend money to borrowers who had similar ESG as the banks, which had a positive impact on the borrowers' subsequent ESG performance. Bătae et al. (2020) studied banks' ESG performance and its relationship with corporate financial performance. Irsyad et al. (2025) found that ESG performance had a significant positive impact on bank stability. Houston & Shan (2022) found in an empirical result that banks were more inclined to lend money to borrowers who had similar ESG as the banks, which had a positive impact on the borrowers' subsequent ESG performance.

Yang and Liu (2012) used the banking industry in Taiwan as the research subject, adopting a two-stage DEA model for evaluation to overcome the

inadequacy of traditional network DEA, which could not be evaluated on a common basis. The research results indicated that the performance of state-owned bank branches was inferior to that of the overall bank branches, and that bank privatization could help improve the inefficiency of state-owned banks. Matthews (2013) used the Bank of China as the research sample with the network data envelope analysis (DEA) adopted. The empirical results indicated that, since political restrictions and development frequently override practical risk management, an excessively high proportion of non-performing loans (NPLs) resulted; also, the training of domestic risk managers was inferior to that of foreign banks. Wang et al. (2014) had a total of 16 major commercial banks in China in 2003-2011 as the research sample and with the Net Slack Based Measure Data Envelopment analysis adopted, dividing the data into two subsystems: deposit generation and profitability. Fukuyama and Matousek (2017), from September 2000 to March 2013, had Japanese banks in operation as the research sample, with a bank network revenue function adopted to evaluate performance. The bank network revenue function was extended to include environmental revenue and costs to reflect the crucial role of non-performing loans

in the production of Japanese banks. Zhou et al. (2019) used Chinese listed commercial banks in 2014-2016 as the research sample, adopting DEA as the research method. The efficiency evaluation is divided into three stages: Capital, capital allocation, and profitability. The empirical results indicated that the efficiency of Chinese listed commercial banks was relatively low. Nathan and Ian (2024) had four major banks in Australia and the UK as the research subjects in the three-year period of 2020-2022 during the outbreak of the COVID-19 pandemic. The constant return to scale DEA technical efficiency analysis was adopted in this study. The empirical results indicated that there was only one bank in Australia and two banks in the UK that achieved perfect technical efficiency.

Research Methods

Research Methods of this study

Several scholars have already adopted Data Envelopment Analysis (DEA) in empirical studies on the impact of the financial industry's profitability or competitiveness on bank operating efficiency.

The Directional Distance Function

(DDF; constant returns to scale) model of the DEA is adopted for research in this study, including radial DDF (RDDF) and non-radial DDF (NDDF). The RDDF has the unexpected output and input reduced proportionally when the expected output is increased. However, the non-radial slacks could be easily ignored, resulting in overstated efficiency. On the contrary, NDDF does not require proportional adjustment of input and output, which is different from the RDDF that measures efficiency through a fixed direction; therefore, NDDF is used to evaluate efficiency from a discretionary direction.

The Directional Distance Function (DDF) model is divided into CRS and VRS models as follows:

1. CRS non-radial DDF model:

$$\begin{aligned} & \max \alpha \\ & s.t. X\lambda + \alpha gx \leq xk \\ & Y\lambda - \alpha gy \geq yk \\ & \lambda \geq 0 \end{aligned} \quad (1)$$

2. VRS non-radial DDF model:

$$\begin{aligned} & \max \alpha \\ & s.t. X\lambda + \alpha gx \leq xk \\ & Y\lambda - \alpha gy \geq yk \end{aligned}$$

$$\sum \lambda = 1$$

$$\lambda \geq 0 \quad (2)$$

Chung et al. (1997) DDF model is adopted in this study, with DN-DDF adopted as the research method to solve related problems such as static and single-stage models, which can objectively and comprehensively observe the overall efficiency and avoid any underestimated or overestimated efficiency.

DMU's efficiency objective function is:

$$\rho_p = \max \sum_{t=1}^T \gamma_t (w_1^t \theta_1^t + w_2^t \theta_2^t)$$

Subject to:

Stage 1: Financial risk

$$\begin{aligned} & \sum_j^n \lambda_{j1}^t x_{ij}^t \leq \theta_1^t x_{ip}^t \quad \forall i, \forall t \\ & \sum_j^n \lambda_{j1}^t z_{dj(1,2)}^t \geq \theta_1^t z_{dp(1,2)}^t \quad \forall d, \forall t \\ & \sum_j^n \lambda_{j1}^t y_{kj}^t \geq \theta_1^t y_{kp}^t \quad \forall k, \forall t \\ & \lambda_{j1}^t \geq 0 \quad \forall j, \forall t \end{aligned}$$

Stage 1: Operating stage

$$\sum_j^n \lambda_{j2}^t f_{bj}^t \leq \theta_2^t f_{bp}^t \quad \forall b, \forall t$$

$$\sum_j^n \lambda_{j2}^t z_{dj(1,2)}^t \geq \theta_2^t z_{dp(1,2)}^t \quad \forall d, \forall t$$

$$\sum_j^n \lambda_{j2}^t n_{aj}^t \geq \theta_2^t n_{ap}^t \quad \forall a, \forall t$$

$$\sum_j^n \lambda_{j2}^t h_{oj(2,3)}^t \geq \theta_2^t h_{op(2,3)}^t \quad \forall o, \forall t$$

$$\lambda_{j2}^t \geq 0 \quad \forall j, \forall t$$

Stage 2: Sustainability

$$\sum_j^n \lambda_{j1}^t E_{gj}^t \leq \theta_1^t E_{gp}^t \quad \forall d, \forall t$$

$$\sum_j^n \lambda_{j3}^t h_{oj(2,3)}^t \geq \theta_3^t h_{op(2,3)}^t \quad \forall o, \forall t$$

$$\sum_j^n \lambda_{j3}^t q_{cj}^t \geq \theta_3^t q_{cp}^t \quad \forall c, \forall t$$

$$\lambda_{j3}^t \geq 0 \quad \forall j, \forall t$$

The link between the two periods

$$\sum_{j=1}^n \lambda_j^{t-1} c_{hj}^t = \sum_{j=1}^n \lambda_j^t c_{hj}^t \quad \forall h, \forall t$$

The link between multiple stages:

$$\begin{aligned} \sum_{j=1}^n \lambda_{j1}^t z_{dj(1,2)}^t \\ = \sum_{j=1}^n \lambda_{j2}^t z_{dj(1,2)}^t \quad \forall d, \forall t \end{aligned}$$

$$\sum_{j=1}^n \lambda_{j2}^t h_{oj(2,3)}^t$$

$$= \sum_{j=1}^n \lambda_{j3}^t h_{oj(2,3)}^t \quad \forall o, \forall t$$

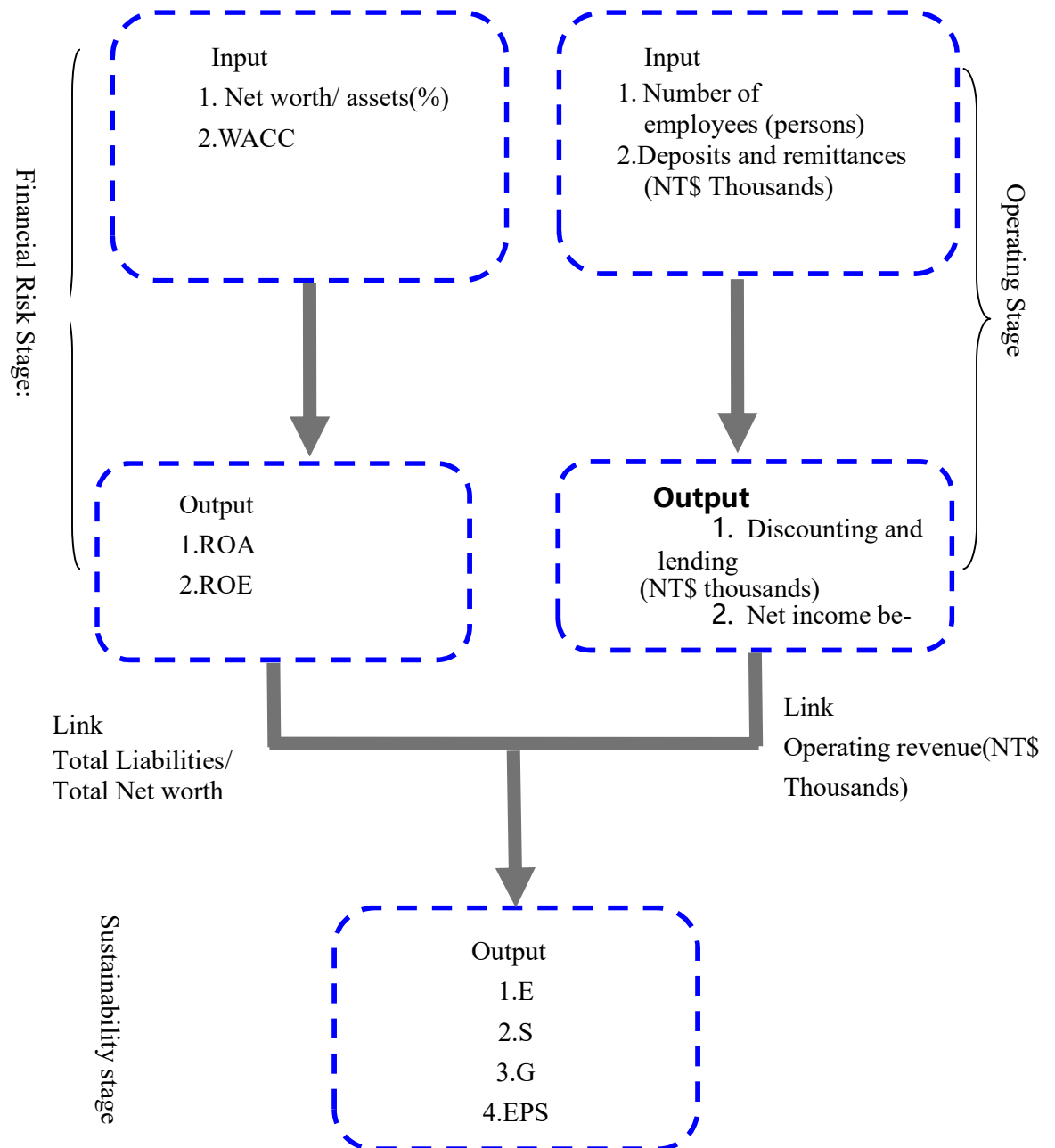
Overall stage efficiency

The overall efficiency is the weighted sum of the periodic efficiency at t, which is expressed as:

$$\rho = \sum_{t=1}^T \gamma_t \rho^t$$

This study is prepared with a total of 37 banks in Taiwan in 2022-2024 as the research sample (Table 1) and with a two-stage DDF DEA adopted.

The input and output variables are explained as follows(Figure 1): 1.1 Financial Risk Stage: Input: Net worth/assets, WACC; Output: ROA and ROE; Link: Debt-to-Equity Ratio. 1.2 Operating Stage: Input: Number of employees, deposits, and remittances; Output: Discounting and lending, net income before tax; Link: Operating Revenue. Stage 2: Output: E, S, G, and EPS. Carry-over: Fixed assets.



t to t+1 Carry-Over Fixed Assets

Data Source: TEJ Database

Figure 1. Taiwan Banking Industry input and output

Table 1. Research Sample of 37 banks in Taiwan

NO	Bank	Abbrevia-	NO	Bank	Abbrevia-
1	EnTie Commercial Bank	ETCB	20	Taishin International Bank	TIB
2	Bank of Panhsin	BOP	21	Taichung Commercial Bank	THCB
3	Bank of Kaohsiung	BOK	22	Taiwan Business Bank	TBB
4	Cathay United Bank	CUB	23	Bank of Taiwan	BOT
5	Taiwan Cooperative Bank	TCB	24	Land Bank of Taiwan	LBOT
6	Citibank Taiwan Limited	CLB	25	O-Bank Co., Ltd.	OB
7	Hwatai Bank	HB	26	Taiwan Shin Kong Commer- cial Bank Co., Ltd.	SKCB
8	Hua Nan Commercial Bank	HNCB	27	DBS Bank (Taiwan) , Ltd.	DBSB
9	HSBC Bank (Taiwan) Lim-	HSBC	28	Sunny Bank	SB
10	NEXT Commercial Bank Co., Ltd.	NCB	29	First Commercial Bank	FCB
11	King's Town Bank	KTB	30	Bank SinoPac Company Lim-	BSC
12	KGI Bank	KGI	31	E.Sun Commercial Bank, Ltd.	ESCB
13	Rakuten International Com- mercial Bank Co., Ltd	RICB	32	Yuanta Commercial Bank Co., Ltd.	YCB
14	LINE Bank Taiwan Limited	LBTL	33	Far Eastern International Bank	FEIB
15	Union Bank of Taiwan	UBOT	34	Standard Chartered Bank (Tai- wan) Limited	SCB
16	Taipei Star Bank	TSB	35	Chang Hwa Commercial Bank	CHB
17	Cota Commercial Bank	CB	36	Mega International Commer- cial Bank Co., Ltd.	MICB
18	The Shanghai Commercial & Savings Bank	SCSB	37	Chinatrust Commercial Bank	CTBC
19	Taipei Fubon Commercial Bank Co., Ltd.	TFCB			

Empirical results

Descriptive statistics

The descriptive statistics of each variable for the banking industry in Taiwan in 2022-2024 are summarized as follows (Table 2).

The annual average net worth/assets ratio was 8.67 in 2022-2024, with a maximum value of 29.05 and a minimum value of 5.02, and a standard deviation of 4.62, indicating a significant difference in the size of the banks in Taiwan. The annual average WACC was

18.36 in 2022-2024, with a maximum value of 140.36 and a minimum value of 11.93, and a standard deviation of 15.52, indicating a large variation in WACC among the banks in Taiwan. The annual average number of employees was 4,561 in 2022-2024, with a maximum of 19,259 employees and a minimum of 164 employees, and a standard deviation of 4,046 employees, indicating a significant difference in size between small and large banks in Taiwan. The annual average deposits and remittances in 2022-2024 were NT\$1,534,947,944 thousand, with a maximum value of NT\$5,331,302,909 thousand and a minimum value of NT\$19,781,213 thousand,

and a significant standard deviation of NT\$1,466,528,354 thousand. The annual average discounts and loans in 2022-2024 were NT\$1,078,142,079 thousand, with a maximum value of NT\$3,768,166,955 thousand and a minimum value of NT\$1,323,976 thousand, and a standard deviation of NT\$1,036,998,025 thousand. The annual average net income before tax in 2022-2024 was NT\$12,710,012 thousand, with a maximum value of NT\$62,827,469 thousand and a minimum value of -NT\$2,509,066 thousand, and a significant standard deviation of NT\$12,935,288 thousand. The annual average operating revenue in 2022-2024 was NT\$1,090,852,091 thousand, with a maximum value of NT\$3,830,994,424 thousand and a minimum value of NT\$650,620 thousand, and a standard deviation of NT\$1,048,711,174 thousand. The annual average ROA in 2022-2024 was 0.34%, with a maximum value of 1.84% and a minimum value of -4.07%, and a standard deviation of 0.95%. The annual average ROE in 2022-2024 was 6.45%, with a maximum value of 15.57% and a minimum value of -18.87%, and a standard deviation of 5.52%. The annual average total liabilities/total net worth ratio in 2022-2024 was 1,234, with a maximum value of 1,891 and a minimum value of 244, and

a standard deviation of 379. The annual average E score in 2022-2024 was 64, with a maximum value of 73 and a minimum value of 55, and a standard deviation of 6. The average S score in 2022-2024 was 65, with a maximum value of 73 and a minimum value of 54, and a standard deviation of 6. The average G score in 2022-2024 was 65, with a maximum value of 73 and a minimum value of 54, and a standard deviation of 6. The average EPS in 2022-2024 was 1.39, with a maximum value of 5.59 and a minimum value of -1.78, and a standard deviation of 1.1.

Overall efficiency and stage efficiency

In terms of overall efficiency in 2022-2024, the ranked top three banks were CTBC Bank (0.9421), Citibank Taiwan (0.9157), and King's Town Bank (0.9102); also, the ranked last three banks were DBS Taiwan (0.2184), Next Bank (0.3438), and Rakuten International Commercial Bank (0.3580) (Tables 3 and 4 and Figure 2).

Table 2. Descriptive statistics on various variables of banking industry in Taiwan from 2022 to 2024

Variable		2022	2023	2024	2022 -2024	Variable		2022	2023	2024	2022 -2024
(I) Net worth/ as-sets(%)	Mean	8.59	8.95	8.48	8.67	(O)ROA (%)	Mean	0.17	0.38	0.47	0.34
	Max	29.05	24.97	20.80	29.05		Max	1.01	1.62	1.84	1.84
	Min	5.02	5.44	5.53	5.02		Min	-4.70	-2.73	-1.74	-4.70
	Std.	5.36	4.90	3.51	4.62		Std.	1.27	0.81	0.65	0.95
(I)WACC	Mean	20.34	18.77	15.98	18.36	(O)ROE (%)	Mean	5.82	6.61	6.92	6.45
	Max	140.36	71.73	42.68	140.36		Max	10.99	15.05	15.57	15.57
	Min	11.93	12.09	12.01	11.93		Min	-	-	-8.33	-18.87
	Std.	23.07	12.90	5.21	15.52		Std.	6.12	5.43	5.04	5.52
(I) Number of employees (per-sons)	Mean	4,457	4,554	4,671	4,561	(L) Total Liabilities/ Total Net Worth	Mean	1,287	1,205	1,212	1,234
	Max	17,767	18,806	19,259	19,259		Max	1,891	1,740	1,707	1,891
	Min	164	164	171	164		Min	244	300	381	244
	Std.	3,898	4,143	4,199	4,046		Std.	409	381	348	379
(I) Deposits and remittances (NT\$ Thousands)	Mean	1,436,231,005	1,525,137,694	1,643,475,133	1,534,947,944	(O)E	Mean	63	64	64	64
	Max	4,670,905,961	5,000,082,385	5,331,302,909	5,331,302,909		Max	73	73	73	73
	Min	19,781,213	21,080,433	35,761,379	19,781,213		Min	55	56	55	55
	Std.	1,387,498,256	1,462,888,372	1,576,130,105	1,466,528,354		Std.	7	6	6	6

(O) Discounting and lending (NT\$ thousands)	Mean	1,005,016,380	1,064,067,099	1,165,342,756	1,078,142,079	(O)S	Mean	64	65	65	65
	Max	3,418,227,678	3,456,020,602	3,768,166,955	3,768,166,955		Max	73	73	73	73
	Min	1,323,976	5,787,473	18,376,134	1,323,976		Min	55	55	54	54
	Std.	985,867,749	1,023,069,151	1,119,694,960	1,036,998,025		Std.	6	6	6	6
(O) Net income be- fore tax (NT\$ sands)	Mean	10,924,296	12,725,582	14,480,158	12,710,012	(O)G	Mean	64	66	66	65
	Max	47,437,605	53,024,903	62,827,469	62,827,469		Max	73	73	73	73
	Min	-2,509,066	-1,473,334	-1,116,640	-2,509,066		Min	55	55	54	54
	Std.	11,204,830	12,727,131	14,738,877	12,935,288		Std.	7	6	6	6
(L)Operating Revenue (NT\$ Thousands)	Mean	1,015,940,676	1,076,792,682	1,179,822,915	1,090,852,091	(O)EPS	Mean	1.19	1.47	1.51	1.39
	Max	3,437,418,409	3,509,045,505	3,830,994,424	3,830,994,424		Max	3.33	5.59	4.52	5.59
	Min	650,620	5,130,636	17,656,218	650,620		Min	-1.78	-1.29	-0.75	-1.78
	Std.	995,803,621	1,034,672,856	1,133,228,084	1,048,711,174		Std.	0.96	1.25	1.08	1.1

The parallel analysis of financial and operational efficiency is adopted in stage 1. The average financial risk in stage 1 is 0.8193, with the best being 1 (BOP, CUB, CLB, HB, HSBC, TBB, SKCB, BSC, MICB, and CTBC) and the lowest being 0.1618 (NCB). The operating efficiency is generally slightly better than the financial risk in stage 1, with the best efficiency being 1 (KTB, SCSB, LBOT) and the worst being 0.4175 (RICB). The financial risk in stage 1 is clearly greater than the operating risk, not only because the lowest efficiency is relatively worse than the operational efficiency, but also because the standard deviation (0.22) is larger than the standard deviation of the operational stage (0.1208). The average sustainability efficiency is 0.5377 in stage 2, with an insignificant standard deviation of 0.1929, the highest efficiency of 0.994 (KTB), and the lowest efficiency of 0.1768 (DBSB). Therefore, the financial risk of the 37 banks in Taiwan may be more severe, with a larger efficiency gap. The average value of 0.5377 in the sustainability stage is too low and needs improvement.

In terms of the financial risk efficiency in stage 1, the average value was 0.7741 in 2022, 0.8075 in 2023, and

0.8763 in 2024. The financial risk of the 37 banks in Taiwan had demonstrated a trend of improvement along with the advancement of the technology industry in Taiwan. The operational efficiency in stage 1 was with an average of 0.7850 in 2022, 0.8139 in 2023, and 0.8342 in 2024. The operational efficiency of the 37 banks in Taiwan had improved along with the development of the technology industry in Taiwan. In terms of the sustainability efficiency in stage 2, the average value was 0.6386 in 2022, 0.4578 in 2023, and 0.5166 in 2024. The average value for each year is too low, and the values for 2023 and 2024 are lower than those for 2022; apparently, the said 37 banks in Taiwan need to improve their sustainability efficiency.

For the overall ranked top three banks: CTBC Bank ranked first in overall efficiency, with a value in the overall efficiency, stage 1 (financial risk and operational efficiency), and sustainability efficiency in stage 2 of (0.9421, 1, 0.8893, 0.9920), respectively, indicating that there is potential for improvement in the operational stage. CTB ranked second with values in overall efficiency, stage 1 (financial risk and operational efficiency), and sustainability efficiency in stage 2 of (0.9157, 1, 0.8665, 0.9538),

respectively, indicating that there is potential for improvement in the operational stage. KTB ranked third, with values in the overall efficiency, stage 1 (financial risk and operational efficiency), and sustainability efficiency in stage 2 of (0.9102, 0.8399, 1, 0.940), respectively, indicating that there is potential for improvement in the financial risk stage.

For the overall ranked last three banks: DBS Bank ranked last in overall efficiency, with values in the overall efficiency, stage 1 (financial risk and operational efficiency), and sustainability efficiency in stage 2 of (0.2184, 0.4943, 0.5698, 0.1768), respectively. Apparently, DBS Bank suffered from a high financial risk and very poor sustainability efficiency. Next Bank ranked second to last, with values in the overall efficiency, stage 1 (financial risk and operational efficiency), and sustainability efficiency in stage 2 of (0.3438, 0.1618, 0.5428, 0.8211), respectively. NCB, as a newly established online bank in 2022, has room for improvement in its financial risk; however, NCB ranked in sixth place in sustainability efficiency, with success within reach. RICB ranked third to last, with values in the overall efficiency, stage 1 (financial risk and operational efficiency), and sustainability

efficiency in stage 2 of (0.3580, 0.4537, 0.4175, 0.8435), respectively. RICB is an online bank that officially started to operate in 2021, with room for improvement in its financial risk and operations; however, it is ranked in fifth place in sustainability efficiency, with success within reach.

Discussion of Empirical Results

This study is prepared with a total of 37 banks in Taiwan from 2022 to 2024 as the research sample and with a two-stage dynamic directional distance function (DN-DDF) adopted. The empirical evidence for this study is as follows:

In terms of overall efficiency, the top three banks among the 37 banks include CTBC, CLB, and KTB, which are long-established banks in Taiwan, and there remains room for their improvement in stage 1. The last three ranked banks include DBSB, NCB, and RICB. DBSB was formerly known as Bowa Bank, which experienced a financial crisis and was subsequently acquired and merged by the DBS Group. However, DBSB's low ranking is due to poor sustainability efficiency, while its financial and operational efficiency is acceptable. NCB and RICB were ranked the second-

to-last and third-to-last, respectively. They are online banks established in 2022 and 2021, respectively, with poor efficiency in stage 1 and stage 2, but their sustainability efficiency is ranked in the top 10. In addition, the so-called state-owned banks, including TCB (ranked 21st), BOT (ranked 20th), LBOT (ranked 24th), and CHB (ranked 26th), all ranked in the lower half of the overall efficiency range and performed poorly in the sustainability stage. State-owned banks should pay more attention to ESG. Overall, the efficiency results in Stage 1 and Stage 2 are satisfactory; however, the sustainability stage has yet to be optimized for improved performance.

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Table 3. Overall efficiency and stage efficiency

NO	DMU	stage 1		stage2	Overall Score	Overall ranking
		stage	stage 1.2			
1	ETCB	0.3921	0.7320	0.3814	0.4178	33
2	BOP	1	0.8514	0.4736	0.6469	18
3	BOK	0.8513	0.7877	0.4293	0.5593	27
4	CUB	1	0.7928	0.6319	0.7578	5
5	TCB	0.8358	0.7944	0.4740	0.6354	21
6	CLB	1	0.8665	0.9538	0.9157	2
7	HB	1	0.8423	0.5162	0.6865	11
8	HNCB	0.9653	0.8042	0.4706	0.6624	14
9	HSBC	1	0.8189	0.5557	0.7328	6
10	NCB	0.1618	0.5428	0.8211	0.3438	36
11	KTB	0.8399	1	0.9940	0.9102	3
12	KGI	0.9255	0.8722	0.4588	0.6259	22
13	RICB	0.4537	0.4175	0.8435	0.3580	35
14	LBTL	0.1863	0.7968	0.6442	0.4101	34
15	UBOT	0.7395	0.8349	0.3426	0.4986	32
16	TSB	0.6709	0.6834	0.8707	0.6848	12
17	CB	0.8037	0.8968	0.5904	0.7020	8
18	SCSB	0.8664	1	0.4799	0.6959	9
19	TFCB	0.9554	0.7613	0.5598	0.6954	10
20	TIB	0.8793	0.8192	0.4755	0.6430	19
21	THCB	0.9197	0.8870	0.4737	0.6615	15
22	TBB	1	0.9502	0.3784	0.6224	23
23	BOT	0.6900	0.8792	0.5241	0.6427	20
24	LBOT	0.7782	1	0.3955	0.6176	24
25	OB	0.8836	0.9234	0.5757	0.6473	17
26	SKCB	1	0.8211	0.4034	0.6062	25
27	DBSB	0.4943	0.5698	0.1768	0.2184	37
28	SB	0.8621	0.8233	0.3468	0.5167	31
29	FCB	0.9811	0.7999	0.5606	0.7191	7
30	BSC	1	0.8090	0.4881	0.6767	13
31	ESCB	0.9238	0.7790	0.4898	0.6555	16
32	YCB	0.8263	0.7320	0.3624	0.5237	30
33	FEIB	0.8013	0.7887	0.3746	0.5277	29
34	SCB	0.8420	0.6928	0.3848	0.5424	28
35	CHB	0.7842	0.8017	0.4049	0.5753	26
36	MICB	1	0.9478	0.5951	0.7919	4
37	CTBC	1	0.8893	0.9920	0.9421	1
mean		0.8193	0.8111	0.5377	0.6235	
max		1	1	0.9940	0.9421	

min	0.1618	0.4175	0.1768	0.2184
Std.	0.2200	0.1208	0.1929	0.1518

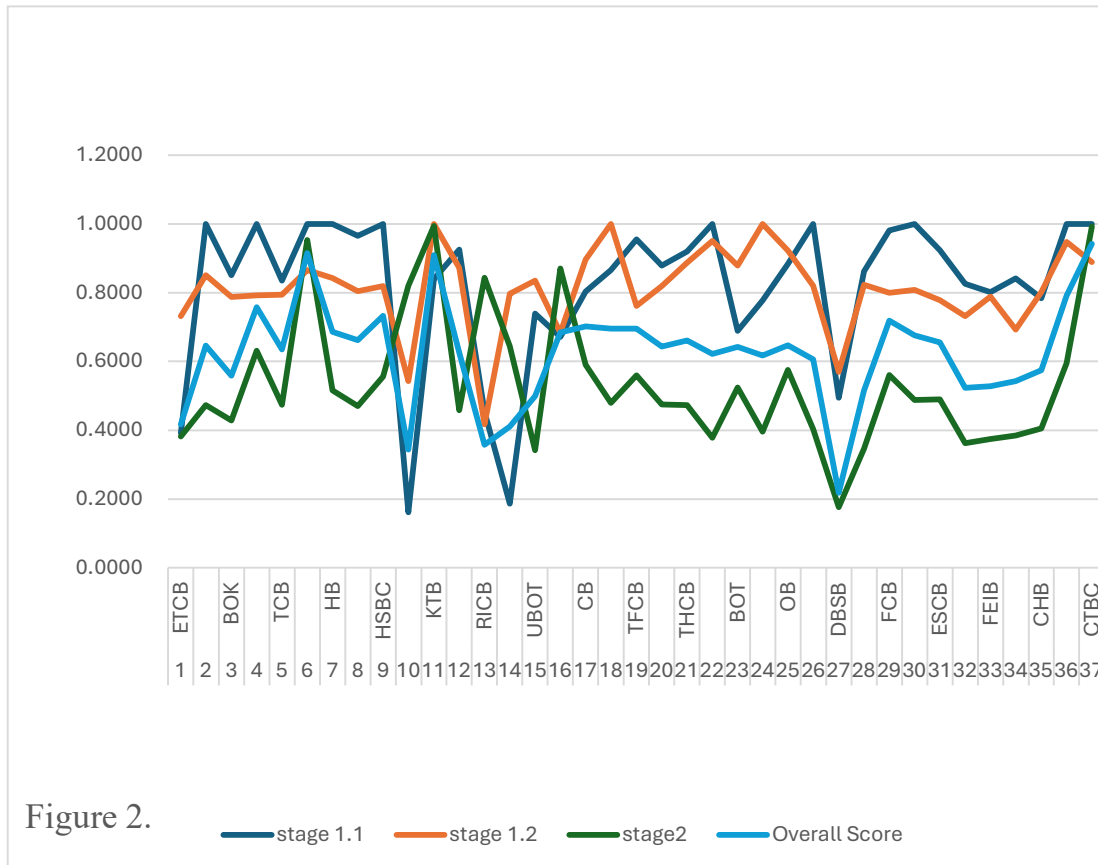


Table 4. 37 of Taiwanese Banks stage Efficiency in 2022-2024

DMU	2022				2023				2024				stage1.		stage1.		stage2	
	stage 1.1	stage1.22	stage2	mean	stage1.1	stage1.2	stage2	mean	stage1.1	stage1.2	stage2	mean	mean	raking	mean	rak-	mean	raking
ETCB	0.4440	0.7382	0.5616	0.5812	0.3082	0.7567	0.2172	0.4273	0.4243	0.7013	0.3653	0.4970	0.3921	35	0.7320	31	0.3814	31
BOP	1	0.7941	0.7010	0.8317	1	1	0.2743	0.7581	1	0.7602	0.4455	0.7352	1	1	0.8514	13	0.4736	23
BOK	1	0.8085	0.7039	0.8374	1	0.7959	0.2498	0.6819	0.5540	0.7588	0.3343	0.5491	0.8513	21	0.7877	28	0.4293	26
CUB	1	0.7709	0.6177	0.7962	1	0.7790	0.5857	0.7882	1	0.8285	0.6924	0.8403	1	1	0.7928	26	0.6319	8
TCB	0.8733	0.8119	0.4736	0.7196	0.7784	0.7777	0.4478	0.6680	0.8558	0.7936	0.5006	0.7167	0.8358	24	0.7944	25	0.4740	21
CLB	1	0.5995	0.8613	0.8203	1	1	1	1	1	1	1	1	1	1	0.8665	12	0.9538	3
HB	1	0.8554	0.7274	0.8609	1	0.8536	0.3133	0.7223	1	0.8179	0.5078	0.7752	1	1	0.8423	14	0.5162	16
HNCB	0.8960	0.7898	0.4739	0.7199	1	0.8425	0.4565	0.7663	1	0.7803	0.4815	0.7539	0.9653	12	0.8042	21	0.4706	24
HSBC	1	0.7731	0.6892	0.8208	1	0.7781	0.4748	0.7509	1	0.9055	0.5031	0.8029	1	1	0.8189	19	0.5557	14
NCB	0.1642	0.2322	0.7935	0.3967	0.1388	0.6545	0.7977	0.5304	0.1825	0.7416	0.8719	0.5987	0.1618	37	0.5428	36	0.8211	6
KTB	0.5197	1	0.9821	0.8340	1	1	1	1	1	1	1	1	0.8399	23	1	1	0.9940	1
KGI	0.9473	0.9006	0.7253	0.8577	0.8292	0.8574	0.3152	0.6673	1	0.8586	0.3359	0.7315	0.9255	14	0.8722	11	0.4588	25
RICB	0.1942	0.1388	0.8417	0.3916	0.1669	0.4516	0.8530	0.4905	1	0.6621	0.8358	0.8326	0.4537	34	0.4175	37	0.8435	5
LBTL	0.1424	0.7107	0.7340	0.5290	0.1833	0.7894	0.5778	0.5168	0.2330	0.8903	0.6209	0.5814	0.1863	36	0.7968	24	0.6442	7
UBOT	0.5604	0.8277	0.5237	0.6373	0.7890	0.8424	0.2305	0.6206	0.8690	0.8347	0.2736	0.6591	0.7395	30	0.8349	15	0.3426	36
TSB	0.6295	0.7663	0.9700	0.7886	0.3830	0.6142	0.7261	0.5744	1	0.6696	0.9161	0.8619	0.6709	32	0.6834	34	0.8707	4
CB	1	0.8581	0.8047	0.8876	0.8108	0.9953	0.4031	0.7364	0.6002	0.8371	0.5633	0.6669	0.8037	26	0.8968	7	0.5904	10
SCSB	1	1	0.4706	0.8235	0.7748	1	0.5543	0.7763	0.8243	1	0.4147	0.7464	0.8664	19	1	1	0.4799	19
TFCB	0.9249	0.7856	0.6089	0.7731	0.9414	0.7474	0.4745	0.7211	1	0.7511	0.5961	0.7824	0.9554	13	0.7613	30	0.5598	13
TIB	0.7326	0.8248	0.5966	0.7180	0.9052	0.8282	0.3899	0.7078	1	0.8047	0.4401	0.7483	0.8793	18	0.8192	18	0.4755	20
THCB	0.7592	0.8847	0.6012	0.7484	1	0.8940	0.3317	0.7419	1	0.8825	0.4881	0.7902	0.9197	16	0.8870	9	0.4737	22
TBB	1	0.9548	0.4895	0.8148	1	0.9370	0.3186	0.7519	1	0.9586	0.3271	0.7619	1	1	0.9502	4	0.3784	32
BOT	0.5401	0.8684	0.5127	0.6404	0.7157	0.8105	0.5291	0.6851	0.8143	0.9588	0.5304	0.7678	0.6900	31	0.8792	10	0.5241	15
LBOT	0.6725	1	0.4303	0.7009	0.8083	1	0.3686	0.7256	0.8539	1	0.3878	0.7472	0.7782	29	1	1	0.3955	29
OB	1	1	0.9978	0.9993	0.9184	0.8662	0.2480	0.6775	0.7324	0.9039	0.4814	0.7059	0.8836	17	0.9234	6	0.5757	11
SKCB	1	0.7959	0.5739	0.7899	1	0.8309	0.3008	0.7105	1	0.8366	0.3354	0.7240	1	1	0.8211	17	0.4034	28
DBSB	0.2789	0.5076	0.2803	0.3556	0.2736	0.4488	0.0576	0.2600	0.9305	0.7529	0.1926	0.6254	0.4943	33	0.5698	35	0.1768	37
SB	1	0.8539	0.5484	0.8008	0.7868	0.8299	0.2137	0.6101	0.7997	0.7862	0.2783	0.6214	0.8621	20	0.8233	16	0.3468	35
FCB	0.9556	0.8159	0.6207	0.7974	0.9877	0.7818	0.5202	0.7632	1	0.8019	0.5411	0.7810	0.9811	11	0.7999	23	0.5606	12
BSC	1	0.7923	0.6110	0.8011	1	0.8305	0.3945	0.7417	1	0.8043	0.4589	0.7544	1	1	0.8090	20	0.4881	18
ESCB	0.8157	0.7530	0.5461	0.7049	0.9558	0.7865	0.4229	0.7217	1	0.7977	0.5005	0.7661	0.9238	15	0.7790	29	0.4898	17
YCB	0.6494	0.7225	0.5008	0.6242	0.8346	0.7386	0.2726	0.6153	0.9950	0.7348	0.3137	0.6812	0.8263	25	0.7320	32	0.3624	34
FEIB	0.6777	0.8074	0.5824	0.6891	0.8616	0.8007	0.2548	0.6390	0.8646	0.7579	0.2867	0.6364	0.8013	27	0.7887	27	0.3746	33
SCB	0.6079	0.527538	0.4806	0.5387	0.9180	0.6116	0.33174	0.6204	1	0.93930	0.3419	0.760415	0.8420	22	0.6928	33	0.3848	30
CHB	0.6561	0.7759	0.4837	0.6386	0.8071	0.8139	0.3461	0.6557	0.8896	0.8152	0.3847	0.6965	0.7842	28	0.8017	22	0.4049	27
MICB	1	1	0.5075	0.8358	1	0.9383	0.6856	0.8746	1	0.9051	0.5923	0.8325	1	1	0.9478	5	0.5951	9
CTBC	1	1	1	1	1	0.8323	1	0.9441	1	0.8355	0.9760	0.9372	1	1	0.8893	8	0.9920	2
Mean	0.7741	0.7850	0.6386	0.7326	0.8075	0.8139	0.4578	0.6931	0.8763	0.8342	0.5166	0.7424	0.8193		0.8111		0.5377	
Max	1	1	1	1	1	1	1	1	1	1	1	1	1		1		0.9940	
Min	0.1424	0.1388	0.2803	0.3556	0.1388	0.4488	0.0576	0.2600	0.1825	0.6621	0.1926	0.4970	0.1618		0.4175		0.1768	

Std.	0.2689	0.1880	0.1741	0.1502	0.2689	0.1337	0.2359	0.1427	0.2142	0.0925	0.2166	0.1090	0.2200	0.12082	0.19294
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