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DETERMINATION OF OVERALL FINANCIAL PERFORMANCE OF PUBLIC SECTOR BANKS IN INDIA

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Abstract- In this paper, financial soundness, and super efficiency and cross efficiency of twenty public sector banks are investigated to predict overall performance of banks through neural network analysis. But, the overall financial performance of banks depends on both financial soundness and financial efficiency. Hence, in this paper, overall financial performance of twenty public sector banks based on both financial soundness and financial efficiency is investigated by considering the weights of the financial ratios derived in previous literature through integrated ANN-GRA-DEA method.
Key words: Artificial Neural Networks, Grey relation analysis, Data envelope method

1. INTRODUCTION

Financial soundness is the primary goal of all business ventures, which is important for viability in the long-run. Traditional financial ratio analysis (FRA) is useful to identify unique bank strengths and weaknesses, which in itself inform bank profitability, liquidity and credit quality. Efficiency is one of the central terms used in assessing and measuring the performance of organizations. Efficiency is concerned with minimizing the cost and deals with the distribution of assets across best alternative uses. Efficiency determines the level of output achieved with a given amount of input, such as cost per unit. A more efficient unit means it obtains a higher level of output using the same amount of input, or it obtains the same level of output using a lower level of input.

Financial efficiency is one of the central terms used in assessing and measuring the performance of organizations. Efficiency is concerned with minimizing the cost and deals with the distribution of assets across best alternative uses. Efficiency determines the level of output achieved with a given amount of input, such as cost per unit. A more efficient unit means it obtains a higher level of output using the same amount of input, or it obtains the same level of output using a lower level of input. Efficiency analysis is essential for the evaluation of bank performance.

2. LITERATURE SURVEY

Chien-Ta Ho (2006) [1] made a study to evaluate the relative performance of three Taiwanese banks using GRA. In the study, it was observed that GRA can still be successfully used in evaluating bank performance although the sample size is small and the distribution of data is unknown.

Nuray Girginer and Nurullah Uçkun (2012) [2] assessed the banks using 14 financial ratios with respect to profitability, liquidity, active quality and capital sufficiency through GRA method.

Funda ÖZÇELİK and Burcu Avci Öztürk (2014) [3] assessed sustainability performance of banks in Turkey through GRA method using specified ratios (Banks' economic, environmental, and social performance). The data was compiled from the banks' sustainability reports of FY 2010-11.

Wen-Tsao Pan and Yungho Leu (2016) [4] considered GRA to assess the levels of service satisfaction of banks. In the study, the effect of different variables on service satisfaction is compared and then these banks are ranked according to their levels of service satisfaction.

Emine Ö ner Kaya (2016) [5] made a study on financial performances of non-life insurance companies traded in Bursa, Istanbul over the period of five years from FY 2009- 10 to FY 2013-14.GRA is adopted in the study with 16 financial ratios under capital adequacy, liquidity, operating, and profitability to rank the financial performance of these banks.

Mehmet Ozcalici (2015) [6] adopted TOPSIS, fuzzy TOPSIS and GRA to forecast the rankings of return on the asset of the Turkish banking sector by utilizing dataset on financial indicators for the FY 2013-14.

Hsiang-Hsi Liu et.al. (2013) [7] considered data envelopment analysis (DEA), three-stage DEA (3SDEA) and artificial neural network (ANN) are employed to measure the technical efficiency of 29 semi-conductor firms in Taiwan. Estimated results show that there are significant differences in efficiency scores among DEA, 3SDEA and ANN analysis. The advanced setting of the three stages mechanism of DEA does show some changes in the efficiency scores between DEA and ANN approaches.

Olanrewaju A Oludolapo et.al. (2012) [8] presented techniques based on the development of multilayer perceptron (MLP) and radial basis function (RBF) of artificial neural network (ANN) models, for calculating the energy consumption of South

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Africa’s industrial sector between 1993 and 2000. The approach examines the energy consumption in relation to the gross domestic product. The results indicate a strong agreement between model predictions and observed values.
Viju Raghupathi and Wullianallur Raghupathi (2015) [9] deployed neural networks to examine the strategic association between hospitalization experience and treatment results. The healthcare data for the years 2009-2012 are downloaded from the Statewide Planning and Research Cooperative System (SPARCS) of the New York State Department of Health (NYSDOH).
Elsa Shokrollahpour et.al. (2016) [10], integrated artificial neural network with DEA to calculate the relative efficiency and more reliable benchmarks of one of the Iranian commercial bank branches. The study is helpful to develop a strategy to improve the efficiency and eliminate the cause of inefficiencies based on a 5-year time forecast of banking authorities.
Financial performance of banks are evaluated and analyzed through integrated method of MLP-GRA method. The proposed methodology is discussed below.

3. INTEGRATED MLP-GRA-DEA

In MLP neural network analysis, the importance of the performance enablers is a measure of how much the network's model-predicted value changes for different values of the independent variable is obtained. The importance of these performance enablers are considered as relative weights for overall performance evaluation of banks which was collected from previous literature.
GRA solves MADM problems by combining the entire range of performance attribute values being considered for every alternative into one single value. This reduces the original problem to a single-objective decision-making problem. The existing GRA with the weight assigned or weight based GRA has good discriminating power for ranking of alternatives. Grey Relation Analysis is used by assigning weight to obtain grey relation coefficient. In this thesis, relative weights are determined through MLP of neural network analysis while predicting the financial performance of banks.
Data envelopment analysis compares the relative efficiency of organizational “units” such as bank branches, hospitals, vehicles, shops and other instances where units perform similar tasks. These units utilize similar resources, referred to as inputs, to generate similar outputs. However, there can be considerable differences in the way in which individual units combine inputs to produce outputs. In addition there may also be differences in potential among units caused by the technology they have available.
But sometimes, pessimistic and optimistic DEA models are used to find the relative importance of units by integrating with GRA without knowing the nature (Input/output) of variables. In this paper an integrated MLP- GRA-DEA methodology is proposed to evaluate the overall financial performance of banks. The Methodology is explained in the following steps.
Step-1: Categorize the Banks based on financial soundness and financial efficiency.
In this paper, MLP is adopted by considering the eighteen performance enablers and the banks are categorized into 3 clusters as collected from previous literature. The three clusters are 1-LL (Low financial soundness and Low financial efficiency; 2-MM (Medium financial soundness and Medium financial efficiency); 3-HH (High financial soundness and High financial efficiency).
Step-2: Determination of relative weights of performance dimensions.
In this paper, relative weights of the performance enablers are obtained in MLP of neural networks analysis obtained from previous literature are considered.
Step-3: Obtain standardized decision matrix.
It is difficult to compare between the different kinds of factors because they exert a different influence. Therefore, the standardized transformation of these factors must be done. The following formulae is used to standardize the data based on the following types of factors.
Benefit type:

$$xs_i(j) = \frac{|x_i(j) - \min x_i(j)|}{\max x_i(j) - \min x(j)} \tag{1}$$

Cost type:

$$xs_i(j) = \frac{\max x_i(j) - x_i(j)}{\max x_i(j) - \min x_i(j)} \tag{2}$$

Nominal type:

$$xs_i(i) = \frac{|x_i(j) - x(j)|}{\max x_i(j) - x(j)} \tag{3}$$

where $x_i(j)$ is the reference value of jth enabler of ith bank.
Step-4: Obtain Prioritized standardized decision matrix
In this thesis, relative importance of the cluster group is considered to obtain prioritized standardized decision matrix from the following relation. The author devised a numerical scale to cluster groups empirically. The priority of the cluster groups is: LL-0.25; MM-0.5; HH-0.10;

$$P\,xs_i(j) = xs_i(j) * CLG_i$$

Pxsi(j) -Value of prioritized jth performance enabler of ith alternative (Bank),
CLGi - numerical value of cluster group of the ith alternative (Bank).
Step-5: Determine absolute differences
The absolute difference in the compared series and the referential series should be obtained by using the following equation.

$$\Delta x_i(j) = \left| x_0(j) - xs_i(j) \right| \tag{4}$$

x0(j)= reference value of jth enabler of ith bank
Step-6: Find out the maximum and minimum absolute differences
The maximum (Δmax) and the minimum (Δmin) difference should be found from the absolute difference of the compared series and the referential series.
Step-7: Determine grey relation coefficient
In Grey relational analysis, Grey relational coefficient ξ can be expressed as shown in equation (5)

$$\xi_i(j) = \frac{\Delta \min + p\Delta \max}{\Delta x_i(j) + p\Delta \max} \tag{5}$$

The distinguishing coefficient p is between 0 and 1. Generally, the distinguishing coefficient p is set to 0.5.
Step-8: Determine optimistic grey relation grade

$$P_k = \max \sum_{j=1}^{n} e_j s_j^+$$

$$\text{s.t.} \quad \sum_{j=1}^{n} \lambda_i \xi_{ij} - s_j^+ = \xi_{kj} \ \forall j \tag{6}$$

$$\sum_{i=1}^{m} \lambda_i = 1$$

$$s_j^+, \lambda_i \geq 0$$

where 1 – Pk indicates the grey relational grade, Γh(k = 1,2,m), for alternative under assessment Ak (known as a DMU in the DEA terminology) and 0 ≤ Pk ≤ 1. s_j^+ is the slack variable of attribute Cj (j = 1,2,...,n), expressing the difference between the performance of a composite alternative and the performance of the assessed alternative with respect to each attribute. In other words, s_j^+ identifies a shortfall in the attribute value of Cj for alternative Ak Obviously, when Pk = 0 alternative Ak is considered as the best alternative in comparison to all the other alternatives, ej is the priority weight of attribute Cj which is defined out of the internal mechanism of frontier for an additive model. The dual of equation (6) can be developed as follows:

$$\Gamma_k = \max \sum_{j=1}^{n} w_j \xi_{kj} - w_0$$

$$\text{s.t.} \quad \sum_{j=1}^{n} w_j \xi_{ij} - w_0 \leq 1 \forall i \tag{7}$$

wj ≥ ej ∀j
w0 free
Step-9: Determine Pessimistic grey relation grade

$$P'_k = \max \sum_{j=1}^{n} e_j s_j^-$$

$$\text{s.t.} \quad \sum_{i=1}^{m} \lambda'_i \xi_{ij} + s_j^- = \xi_{kj} \ \forall j \tag{8}$$

$$\sum_{i=1}^{m} \lambda'_i = 1$$

$$s_j^-, \lambda'_i \geq 0$$

Note that the only difference between equation (6) and equation (8) is the signs of slack variables in the first set of constraint, sf is the slack variable of attribute Cj (j = 1,2,...,n), expressing the difference between the performance of the assessed alternative and the performance of a composite alternative with respect to each attribute. The dual model of equation (8) is shown below.

$$\Gamma'_k = \max \sum_{j=1}^{n} w'_j \xi_{kj} + w'_0$$

$$\text{s.t.} \quad \sum_{j=1}^{n} w'_j \xi_{ij} + w'_0 \geq 1 \forall i \qquad (9)$$

$$w'_j \geq e_j \ \forall j$$

w'_0 free.

Step-10: Determine normalized grey relation grade

To combine the grey relational grades obtained equation (7) and (9), that is the best and worst sets of weights, the linear combination of corresponding normalized grades is recommended as follows:

$$\Delta_k(\beta) = \beta \frac{\Gamma_k - \Gamma_{min}}{\Gamma_{max} - \Gamma_{min}} + (1-\beta) \frac{\Gamma'_k - \Gamma'_{min}}{\Gamma'_{max} - \Gamma'_{min}} \qquad (10)$$

where Γmax = max{Γk, k = 1,2,…,m},Γmin = min{Γk, k = 1,2,…,m}, Γ'_{max} = max{ Γ'_k , k = 1,2,…,m}, { Γ'_{min} = min{ Γ'_k , k = 1,2,…,m} and 0 ≤ β ≤ 1 is an adjusting parameter, which may reflect the preference of a decision-maker on the best and worst sets of weights. Δk(β) is a normalized compromise grade in the range [0, 1].

Step-11: Determine Ranking of Alternatives

Alternatives are ranked basing on the descending order of normalized relation grade.

4. RESULTS AND DISCUSSION

In this paper integrated MLP-GRA-DEA method as discussed in methodology are implemented for twenty Indian public sector banks to evaluate the overall financial performance of these banks

4.1 Relative weights of performance criteria –

Normalized importance of the criteria which impact overall financial performance category of banks is obtained from previous literature is considered as relative weights of criteria of overall financial performance and is presented in Table-1.

Table-1 Relative Weights of Financial Ratios

Variable	Relative Weights	Variable	Relative Weights
CA1	0.0538	EQ1	0.0610
CA2	0.0568	EQ2	0.0609
CA3	0.0564	EQ3	0.0580
AQ1	0.0574	EQ4	0.0511
AQ2	0.0556	LI1	0.0503
AQ3	0.0529	LI2	0.0535
ME1	0.0516	LI3	0.0548
ME2	0.0682	LI4	0.0509
ME3	0.0523	EPS	0.0544

4.2 Data on financial ratios –

The data on seventeen performance enablers under five performance dimensions for 20 banks for one year is collected from previous literature is presented below Table-2.

Table-2 Data on Financial Ratios

Bank	CA1	CA2	CA3	AQ1	AQ2	AQ3	ME1	ME2	ME3	EQ1	EQ2	EQ3	EQ4	LI1	LI2	LI3	LI4	EPS
Bank l	12.96	61.89	81.25	0.79	0.49	28.59	10.63	6.70	70.99	111	2.23	2.02	88.93	5.22	23.23	5.99	59.91	31.85
Bank 2	14.38	65.60	93.87	0.38	0.25	22.23	11.65	9.00	77.52	1.36	2.95	2.22	90.24	6.60	20.86	7.80	100.34	26.05
Bank 3	14.52	63.81	83.23	0.35	0.22	19.92	12.29	11.00	74.87	1.33	0.87	1.95	88.62	5.54	16.58	6.50	85.88	116.37

Bank 4	12.17	60.68	80.71	0.91	0.55	24.45	12.84	6.20	71 30	0.82	0.54	1.53	89.17	6.20	24.78	7.29	129.11	47.35
Bank 5	13.35	61.33	82.44	1.32	0.81	29.42	8.25	2.38	70.13	0.47	3.69	112	91.29	5.03	24.26	5.75	58.28	6.86
Bank 6	15.38	62.89	85.07	1.10	0.69	24.90	11.99	9.76	72.00	1.42	0.93	1.81	89.08	6.55	21.18	7.50	89.86	97.83
Bank 7	11.64	61.85	87.62	0.65	0.40	25.98	8.35	3.96	72.33	0.70	1.58	1.24	92.33	6.71	22.77	7.85	91 26	27.69
Bank 8	14.11	60.52	64.65	0.46	0.28	30.28	15.73	10.92	74.39	1.21	1.99	1.78	87.91	5.67	19.57	6.97	57.87	98.50
Bank 9	13.64	62.00	79.12	1.06	0.66	26.94	23.46	11.93	87.04	0.73	8.29	1.64	89.64	7.72	21.32	10.84	82.38	18.37
Bank 10	13.56	61.82	75.67	0.53	0.33	28.58	9.30	8.88	71.12	1.53	3.08	2.70	88.79	5.65	21.62	6.50	106.81	38.79
Bank 11	14.55	62.55	98.17	1.19	0.74	27.19	10.05	4.16	77.00	0.71	1.74	1.60	90.81	5.60	26.69	6.89	84.80	19.63
Bank 12	14.23	59.44	73.87	0.98	0.58	30.71	14.18	9.04	68.97	1.03	1.65	2.01	92.64	5.90	22.68	6.84	101.25	45.29
Bank 13	12.42	63.99	83.54	0.85	0.54	25.15	10.18	8.35	77.38	1.34	1.05	2.39	88.19	6.28	21.01	7.60	88.60	140.60
Bank 14	11.68	65.45	97.16	0.83	0.54	21 48	7.51	5.00	76.52	0.96	5.37	1.81	88.23	8.54	20.87	9.98	150 18	101.53
Bank 15	11.98	61.84	78.82	1.63	1.01	24.16	7.04	3.84	81 03	0.71	2.71	2.07	83.72	17.30	42.69	22.66	71 95	130 16
Bank 16	12.54	64.87	80.11	0.98	0.64	25.26	8.88	8.00	79.17	112	3.66	1.66	90.00	6.64	20.23	8.10	160.67	145.55
Bank 17	13.04	68.21	86.41	0.97	0.66	22.40	8.75	3.99	78.75	0.76	2.17	1.76	92.60	6.67	19.36	7.70	97.25	20.03
Bank 18	13.71	60.63	83.69	1.84	1.12	26.27	10.69	4.19	68.19	0.66	1.88	1.65	92.47	6.37	29.01	7.16	135.60	14.29
Bank 19	12.95	63.98	79.57	1.19	0.76	24.75	10.43	8.00	74.58	1.05	1.41	1.82	88.97	7.46	22.37	8.70	89.77	39.71
Bank 20	13.05	59.42	72.83	1.42	0.84	29.16	8.60	3.48	68.73	0.66	3.54	1.67	90.87	6.60	21.24	7.63	69.69	14.38

4.3 Prioritized Standardized Matrix

The standardized transformation of the criteria is done as discussed in step 3. The performance criteria under Asset Quality are considered as cost type. Other performance enablers are considered as benefit type. Standardized data for one financial year is shown in Table-3 below.

Table-3 Prioritized Standardized Financial Ratios

Bank	CA1	CA2	CA3	AQ1	AQ2	AQ3	M E1	ME2	ME3	EQ1	EQ2	EQ3	EQ4	LI1	LI2	LI3	LI4	EPS
Bank l	0.1765	0.1402	0.2477	0.3523	0.3515	0.0984	0.1093	0.2262	0.0741	0.3019	0.1093	0.2839	0.2922	0.0078	0.1273	0.0070	0.0099	0.0901
Bank 2	0.3663	0.3512	0.4358	0.4899	0.4829	0.3932	0.1404	0.3466	0.2473	0.4198	0.1553	0.3460	0.3652	0.0638	0.0820	0.0604	0.2066	0.0692
Bank 3	0.7701	0.4986	0.5544	1.0000	1.0000	1.0000	0.3197	0.9026	0.3541	0.8113	0.0425	0.5231	0.5496	0.0418	0.0000	0.0444	0.2725	0.7896
Bank 4	0.1417	0.1434	0.4793	0.6242	0.6281	0.5799	0.3532	0.4000	0.1646	0.3302	0.0000	0.2615	0.6108	0.0955	0.3141	0.0907	0.6930	0.2919
Bank 5	0.1143	0.0542	0.1327	0.0872	0.0856	0.0298	0.0184	0.0000	0.0257	0.0000	0.1016	0.0000	0.2121	0.0000	0.0735	0.0000	0.0010	0.0000
Bank 6	1.0000	0.3943	0.6093	0.4948	0.4722	0.5388	0.3015	0.7728	0.2018	0.8962	0.0500	0.4381	0.6009	0.1241	0.1761	0.1034	0.3112	0.6559
Bank 7	0.0000	0.1379	0.3427	0.3993	0.3978	0.2189	0.0399	0.0827	0.1097	0.1085	0.0669	0.0369	0.4823	0.0686	0.1185	0.0620	0.1624	0.0751

Bank 8	0.6604	0.1250	0.0000	0.9262	0.9370	0.0398	0.5292	0.8942	0.3288	0.6981	0.1865	0.4169	0.4699	0.0524	0.1146	0.0722	0.0000	0.6608
Bank 9	0.2674	0.1468	0.2159	0.2617	0.2536	0.1745	0.5000	0.5000	0.5000	0.1226	0.5000	0.1647	0.3316	0.1096	0.0907	0.1503	0.1192	0.0415
Bank 10	0.2567	0.1366	0.1644	0.4396	0.4411	0.0988	0.0688	0.3403	0.0777	0.5000	0.1639	0.5000	0.2841	0.0253	0.0966	0.0221	0.2380	0.1151
Bank 11	0.1945	0.0890	0.2500	0.1091	0.1042	0.0815	0.0458	0.0466	0.1169	0.0566	0.0387	0.0759	0.1986	0.0116	0.0968	0.0168	0.0655	0.0230
Bank 12	0.3463	0.0013	0.1376	0.2886	0.2987	0.0000	0.2174	0.3487	0.0206	0.2642	0.0715	0.2815	0.5000	0.0353	0.1169	0.0322	0.2110	0.1385
Bank 13	0.2086	0.5201	0.5637	0.6644	0.6449	0.5149	0.1911	0.6251	0.4871	0.8208	0.0653	0.8041	0.5013	0.1022	0.1698	0.1091	0.2989	0.9643
Bank 14	0.0107	0.6862	0.9700	0.6779	0.6411	0.8558	0.0286	0.2743	0.4416	0.4623	0.6232	0.4368	0.5056	0.2861	0.1642	0.2502	0.8980	0.6826
Bank 15	0.0909	0.2748	0.4227	0.1409	0.1202	0.6074	0.0000	0.1529	0.6808	0.2264	0.2804	0.6002	0.0000	1.0000	1.0000	1.0000	0.1370	0.8890
Bank 16	0.2406	0.6200	0.4613	0.5772	0.5371	0.5053	0.1121	0.5885	0.5824	0.6132	0.4030	0.3394	0.7033	0.1308	0.1399	0.1386	1.0000	1.0000
Bank 17	0.0936	0.2500	0.1623	0.1460	0.1278	0.1925	0.0260	0.0421	0.1400	0.0684	0.0526	0.1006	0.2488	0.0334	0.0266	0.0288	0.0958	0.0237
Bank 18	0.1384	0.0344	0.1420	0.0000	0.0000	0.1028	0.0556	0.0474	0.0000	0.0448	0.0432	0.0837	0.2453	0.0272	0.1190	0.0208	0.1890	0.0134
Bank 19	0.0876	0.1297	0.1113	0.1091	0.0983	0.1382	0.0516	0.1471	0.0846	0.1368	0.0281	0.1113	0.1472	0.0496	0.0554	0.0435	0.0776	0.0592
Bank 20	0.0943	0.0000	0.0610	0.0705	0.0769	0.0358	0.0238	0.0288	0.0071	0.0448	0.0969	0.0875	0.2004	0.0320	0.0446	0.0278	0.0287	0.0136

4.4 Absolute difference in the compared series and the referential series –

The absolute difference in the compared series and the referential series are obtained as discussed in step 4 is presented in Table-4.

Table-4 Absolute Difference

Bank	CA1	CA2	CA3	AQ1	AQ2	AQ3	M E1	ME2	ME3	EQ1	EQ2	EQ3	EQ4	LI1	LI2	LI3	LI4	EPS
Bank l	0.8235	0.8598	0.7523	0.6477	0.6485	0.9016	0.8907	0.7738	0.9259	0.6981	0.8907	0.7161	0.7078	0.9922	0.8727	0.9930	0.9901	0.9099
Bank 2	0.6337	0.6488	0.5642	0.5101	0.5171	0.6068	0.8596	0.6534	0.7527	0.5802	0.8447	0.6540	0.6348	0.9362	0.9180	0.9396	0.7934	0.9308
Bank 3	0.2299	0.5014	0.4456	0.0000	0.0000	0.0000	0.6803	0.0974	0.6459	0.1887	0.9575	0.4769	0.4504	0.9582	1.0000	0.9556	0.7275	0.2104
Bank 4	0.8583	0.8566	0.5207	0.3758	0.3719	0.4201	0.6468	0.6000	0.8354	0.6698	1.0000	0.7385	0.3892	0.9045	0.6859	0.9093	0.3070	0.7081
Bank 5	0.8857	0.9458	0.8673	0.9128	0.9144	0.9702	0.9816	1.0000	0.9743	1.0000	0.8984	1.0000	0.7879	1.0000	0.9265	1.0000	0.9990	1.0000
Bank 6	0.0000	0.6057	0.3907	0.5052	0.5278	0.4612	0.6985	0.2272	0.7982	0.1038	0.9500	0.5619	0.3991	0.8759	0.8239	0.8966	0.6888	0.3441
Bank 7	1.0000	0.8621	0.6573	0.6007	0.6022	0.7811	0.9601	0.9173	0.8903	0.8915	0.9331	0.9631	0.5177	0.9314	0.8815	0.9380	0.8376	0.9249
Bank 8	0.3396	0.8750	1.0000	0.0738	0.0630	0.9602	0.4708	0.1058	0.6712	0.3019	0.8135	0.5831	0.5301	0.9476	0.8854	0.9278	1.0000	0.3392
Bank 9	0.7326	0.8532	0.7841	0.7383	0.7464	0.8255	0.5000	0.5000	0.5000	0.8774	0.5000	0.8353	0.6684	0.8904	0.9093	0.8497	0.8808	0.9585
Bank 10	0.7433	0.8634	0.8356	0.5604	0.5589	0.9012	0.9312	0.6597	0.9223	0.5000	0.8361	0.5000	0.7159	0.9747	0.9034	0.9779	0.7620	0.8849
Bank 11	0.8055	0.9110	0.7500	0.8909	0.8958	0.9185	0.9542	0.9534	0.8831	0.9434	0.9613	0.9241	0.8014	0.9884	0.9032	0.9832	0.9345	0.9770
Bank 12	0.6537	0.9987	0.8624	0.7114	0.7013	1.0000	0.7826	0.6513	0.9794	0.7358	0.9285	0.7185	0.5000	0.9647	0.8831	0.9678	0.7890	0.8615

Bank 13	0.7914	0.4799	0.4363	0.3356	0.3551	0.4851	0.8089	0.3749	0.5129	0.1792	0.9347	0.1959	0.4987	0.8978	0.8302	0.8909	0.7011	0.0357
Bank 14	0.9893	0.3138	0.0300	0.3221	0.3589	0.1442	0.9714	0.7257	0.5584	0.5377	0.3768	0.5632	0.4944	0.7139	0.8358	0.7498	0.1020	0.3174
Bank 15	0.9091	0.7252	0.5773	0.8591	0.8798	0.3926	1.0000	0.8471	0.3192	0.7736	0.7196	0.3998	1.0000	0.0000	0.0000	0.0000	0.8630	0.1110
Bank 16	0.7594	0.3800	0.5387	0.4228	0.4629	0.4947	0.8879	0.4115	0.4176	0.3868	0.5970	0.6606	0.2967	0.8692	0.8601	0.8614	0.0000	0.0000
Bank 17	0.9064	0.7500	0.8377	0.8540	0.8722	0.8075	0.9740	0.9579	0.8600	0.9316	0.9474	0.8994	0.7512	0.9666	0.9734	0.9712	0.9042	0.9763
Bank 18	0.8616	0.9656	0.8580	1.0000	1.0000	0.8972	0.9444	0.9526	1.0000	0.9552	0.9568	0.9163	0.7547	0.9728	0.8810	0.9792	0.8110	0.9866
Bank 1 9	0.9124	0.8703	0.8887	0.8909	0.9017	0.8618	0.9484	0.8529	0.9154	0.8632	0.9719	0.8887	0.8528	0.9504	0.9446	0.9565	0.9224	0.9408
Bank 20	0.9057	1.0000	0.9390	0.9295	0.9231	0.9642	0.9762	0.9712	0.9929	0.9552	0.9031	0.9125	0.7996	0.9680	0.9554	0.9722	0.9713	0.9864

4.5 Grey Relation Coefficients

Maximum and minimum absolute differences are found as discussed in step 5. The grey relation coefficient is described as discussed in step 6 presented in Table-5.

Table-5 Gray Relation Coefficients

Bank	CA1	CA2	CA3	AQ1	AQ2	AQ3	M E1	ME2	ME3	EQ1	EQ2	EQ3	EQ4	LI1	LI2	LI3	LI4	EPS
Bank l	0.3778	0.3677	0.3993	0.4357	0.4354	0.3567	0.3595	0.3925	0.3507	0.4173	0.3595	0.4112	0.4140	0.3351	0.3642	0.3349	0.3356	0.3546
Bank 2	0.4410	0.4352	0.4699	0.4950	0.4916	0.4517	0.3677	0.4335	0.3991	0.4629	0.3718	0.4333	0.4406	0.3481	0.3526	0.3473	0.3866	0.3495
Bank 3	0.6850	0.4993	0.5288	1.0000	1.0000	1.0000	0.4236	0.8370	0.4363	0.7260	0.3431	0.5118	0.5261	0.3429	0.3333	0.3435	0.4073	0.7038
Bank 4	0.3681	0.3686	0.4899	0.5709	0.5735	0.5434	0.4360	0.4545	0.3744	0.4274	0.3333	0.4037	0.5623	0.3560	0.4216	0.3548	0.6196	0.4139
Bank 5	0.3608	0.3458	0.3657	0.3539	0.3535	0.3401	0.3375	0.3333	0.3392	0.3333	0.3575	0.3333	0.3882	0.3333	0.3505	0.3333	0.3336	0.3333
Bank 6	1.0000	0.4522	0.5613	0.4974	0.4865	0.5202	0.4172	0.6875	0.3852	0.8281	0.3448	0.4708	0.5561	0.3634	0.3777	0.3580	0.4206	0.5924
Bank 7	0.3333	0.3671	0.4320	0.4543	0.4536	0.3903	0.3424	0.3528	0.3596	0.3593	0.3489	0.3417	0.4913	0.3493	0.3619	0.3477	0.3738	0.3509
Bank 8	0.5955	0.3636	0.3333	0.8713	0.8880	0.3424	0.5151	0.8254	0.4269	0.6235	0.3807	0.4616	0.4854	0.3454	0.3609	0.3502	0.3333	0.5958
Bank 9	0.4056	0.3695	0.3894	0.4038	0.4012	0.3772	0.5000	0.5000	0.5000	0.3630	0.5000	0.3745	0.4279	0.3596	0.3548	0.3705	0.3621	0.3428
Bank 10	0.4022	0.3667	0.3744	0.4715	0.4722	0.3568	0.3494	0.4312	0.3515	0.5000	0.3742	0.5000	0.4112	0.3390	0.3563	0.3383	0.3962	0.3610
Bank 11	0.3830	0.3544	0.4000	0.3595	0.3582	0.3525	0.3438	0.3440	0.3615	0.3464	0.3422	0.3511	0.3842	0.3359	0.3563	0.3371	0.3486	0.3385
Bank 12	0.4334	0.3336	0.3670	0.4127	0.4162	0.3333	0.3898	0.4343	0.3380	0.4046	0.3500	0.4103	0.5000	0.3414	0.3615	0.3406	0.3879	0.3673
Bank 13	0.3872	0.5103	0.5340	0.5984	0.5847	0.5076	0.3820	0.5715	0.4936	0.7361	0.3485	0.7185	0.5006	0.3577	0.3759	0.3595	0.4163	0.9334
Bank 14	0.3357	0.6144	0.9434	0.6082	0.5822	0.7761	0.3398	0.4079	0.4724	0.4818	0.5703	0.4703	0.5028	0.4119	0.3743	0.4001	0.8306	0.6117
Bank 15	0.3548	0.4081	0.4641	0.3679	0.3624	0.5602	0.3333	0.3712	0.6103	0.3926	0.4100	0.5557	0.3333	1.0000	1.0000	1.0000	0.3668	0.8184
Bank 16	0.3970	0.5682	0.4814	0.5418	0.5193	0.5027	0.3602	0.5485	0.5449	0.5638	0.4558	0.4308	0.6276	0.3652	0.3676	0.3673	1.0000	1.0000
Bank 17	0.3555	0.4000	0.3738	0.3693	0.3644	0.3824	0.3392	0.3430	0.3677	0.3493	0.3455	0.3573	0.3996	0.3409	0.3393	0.3399	0.3561	0.3387

Bank 18	0.3672	0.3412	0.3682	0.3333	0.3333	0.3579	0.3462	0.3442	0.3333	0.3436	0.3432	0.3530	0.3985	0.3395	0.3621	0.3380	0.3814	0.3363
Bank 19	0.3540	0.3649	0.3601	0.3595	0.3567	0.3671	0.3452	0.3696	0.3533	0.3668	0.3397	0.3600	0.3696	0.3447	0.3461	0.3433	0.3515	0.3470
Bank 20	0.3557	0.3333	0.3475	0.3498	0.3513	0.3415	0.3387	0.3399	0.3349	0.3436	0.3563	0.3540	0.3847	0.3406	0.3435	0.3396	0.3398	0.3364

Optimistic and Pessimistic grey relation grade:

Optimistic and pessimistic grey relation grades are obtained by solving the dual models as discussed in methodology was solved using Lingo solver 8.0. Lingo code is developed to solve the optimization models. Optimistic and pessimistic grey relation grades are shown in Table-6.

Table-6 Optimistic and Pessimistic Grades

Bank	Γi	Γ′i	Bank	Γi	Γ′i
Bank l	0.7877	1.0332	Bank 11	0.7592	1.0095
Bank 2	0.8275	1.0709	Bank 12	0.7914	1.0394
Bank 3	1.0000	1.2517	Bank 13	0.9283	1.1756
Bank 4	0.8539	1.1016	Bank 14	1.0000	1.1942
Bank 5	0.7530	1.0000	Bank 15	1.0000	1.1881
Bank 6	0.9280	1.1761	Bank 16	0.9667	1.1888
Bank 7	0.7839	1.0321	Bank 17	0.7623	1.0130
Bank 8	0.9259	1.1665	Bank 18	0.7554	1.0050
Bank 9	0.8487	1.0612	Bank 19	0.7585	1.0100
Bank 10	0.8111	1.0537	Bank 20	0.7526	1.0004

Banks are ranked basing on the descending order of normalized grey relation grade. Normalized grey relation grades and Ranking of Banks are shown in Table-7.

Table-7 Ranking of Banks Based on Overall Performance

Bank	Normalized Grey Relation Grade	Rank	Ban k	Normalized Grey Relation Grade	Rank
Bank 1	0.1368	13	Bank 11	0.0322	16
Bank 2	0.2923	10	Bank 12	0.1566	12
Bank 3	1.0000	1	Bank 13	0.7039	6
Bank 4	0.4066	8	Bank 14	0.8858	2
Bank 5	0.0008	19	Bank 15	0.8736	3
Bank 6	0.7044	5	Bank 16	0.8077	4
Bank 7	0.1270	14	Bank 17	0.0455	15
Bank 8	0.6810	7	Bank 18	0.0154	18
Bank 9	0.3159	9	Bank 19	0.0318	17
Bank 10	0.2248	11	Bank 20	0.0008	20

From Table-7 it is observed that, Bank 3 is obtained as the highest overall financial performance since the normalized grey relation grade is obtained as 1.000. Bank 20 is obtained as the lowest overall financial performance since the normalized grey relation grade is obtained as 0.000.

5. CONCLUDING REMARKS

Due to radical changes in the banking sector in the recent years, the banks all around the world have improved their supervision quality and techniques. In evaluating the function of the banks, many of the developed countries are now following uniform financial rating system (CAMEL RATING). In this thesis, five performance dimensions and seventeen enablers are considered to rank the banks through integrated method AHM-GRA-DEA based on financial soundness perspective. In this paper, overall financial performance of banks is determined by considering both financial soundness and financial efficiency through integrated MLP-GRA-DEA method. Future research may utilize several other techniques to investigate the casual relationships among performance evaluation indices of different methods to objectively build strategy maps. Finally, exploring more cases and conducting more empirical studies are recommended to further validate the usefulness of the proposed performance evaluation models.

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