

A hybrid unsupervised learning and multi-criteria decision making approach for performance evaluation of Indian banks

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ABSTRACT

Efficient and stable performance of the banking system underpins sustainable growth of any economy. Of late, several economic reforms have been initiated in India for facilitating growth and withstanding dynamics of global economy. In this context, the current study compares the performance of the selected private and public sector banks in India on a five year time horizon in order to discern any changes in the performance over a period of time. First, the performance of the selected banks are examined in terms of management efficiency perspective using a Multi-Criteria Decision Making (MCDM) technique such as Combinative Distance-based Assessment (CODAS) when an Entropy method is also employed for determining criteria weight. The study also applies k-Means Clustering for checking consistency of performance based ranking with asset management efficiency. Finally, the paper delves into the relationship between financial and market performance. The study has found consistent results and observed private sector banks perform better than the public sector.

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1. Introduction

Banks are playing key role in any economy. Stability in the banking system and sustainable performance of banks not only maintains optimum utilization of financial resources, but also ensures effective financial flow across the components of the economy. Hence, banks are instrumental in economic growth and inclusive development of any country. The Indian economy has witnessed continuous reform and structural changes starting from early 90's. Alongside the world, economy has also encountered several changes. Recent past incidents like the bankruptcy of Lehman Brothers in 2008 leading to the global economic crisis, Brexit, devaluation of yuan, Greece debt crisis, a rise in US debt, slump in Japanese economy due to natural calamity, continuous war against terrorism, to name a few, have significantly impacted the world economy. In India, we have seen some major reforms like demonetization, the emergence of the digital economy, GST in the last few years. The banking sector in India consists of mainly two types of ownership groups: Public and Private (Domestic and Foreign). In addition, there are regional rural banks, urban and rural cooperative banks. In the sense, the Indian

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banking sector is a complex system regulated by RBI. Though, the banks are controlled by regulatory norms, owing to the dynamic global economic environment and varying requirements by other components of the economy, performance of banks are not homogeneous. Though recent studies related to credit, market and liquidity risk have noted the resilient nature of the Indian banking system by its inherent system to withstand global economic turbulence, but, it is imperative to study bank performance for ensuring sustained profitability while minimizing risk. Hence, this area has always attracted the researchers and practitioners. Moreover, as India is growing at a considerable pace, it necessitates a comparative study of private and public sector banks in India.

Over the years, there has been a plethora of research being conducted on assessment of banking performance. Way back Beaver (1966, 1968) and Altman (1968) worked on performance assessment of banks in the context of bankruptcy prediction where they used financial ratios for their analysis. The study of Kwan and Eisenbeis (1997) reported asset quality is a useful indicator of risk and capitalization which determine the efficiency of operation of financial institutions. In tune with the work of Altman (1968) proposing a Z-score model for banks, Maishanu (2004) assessed financial health of banks using ratios while Mous (2005) attempted to predict bankruptcy through a comparative study using decision tree model and multiple discriminant models wherein the author reported better result for decision tree model.

CAMEL approach has been a widely accepted framework for assessing relative financial performance of banks while unfolding areas to improve. CAMEL approach incorporates parameters like Capital Adequacy, Assets Quality, Management Efficiency, Earnings Quality and Liquidity. In essence, it provides a broader outlook of bank performance. Based on the recommendation of Padmanabham Working Group (1995) committee, in 1996, RBI has adopted this framework. The CAMEL framework covers different aspects of bank performance reflected through a significant number of ratios. It has been a popular approach for evaluating bank performance and recommending measures for bank stability (Ayadi et al., 1998; Said & Saucier, 2003; Sarker, 2005; Gupta & Kaur, 2008; Hays et al., 2009; Maliszewski, 2009; Njoku, 2011; Klomp & de Haan, 2011; Bhattacharyay, 2011; Njoku & Inanga, 2012; Dash & Das, 2013; Sayed & Sayed, 2013; Popovska, 2014).

However, it is noteworthy that, Multi-Criteria Decision Making (MCDM) approaches have emerged as a growing stream of the literature, which has been applied by several researchers for assessing bank performance (Doumpos & Zopounidis, 2015). MCDM techniques are well applied in solving complex economic decision making problems, and improving robustness of financial analysis (Balzentis et al., 2012). The literature is rife with applications of a variety of MCDM methods and techniques for understanding and ranking performance of banks. The following table (Table 1) summarizes some of work in the stated field using various MCDM techniques.

Data Envelopment Analysis (DEA) has been a widely used for risk measurement and monitoring and assessment and ranking of banking based on performance by measuring the efficiency of banking operations based on the parameters like labor, capital and deposits of the banks (input); credits, other earnings assets, and off-balance sheet activities (output). There are three broad streams of research observed in the literature. Research belong to first stream focus on assessing bank performance using financial statement based ratios related to CAMEL framework like return on assets (ROA), return on equity (ROE), net interest margin (NIM), return on investments (ROI), debt-equity ratio, capital adequacy ratio, total advances to total deposit ratio, return on net worth etc. The second stream evaluates the banks from the perspective of balanced scorecard measures (Kaplan and Norton, 1996). In this case, researchers have considered financial position, internal process efficiency, customer satisfaction room for learning and development of internal stakeholders such as employees. Here lies the linkage with the third stream, which focuses on customer satisfaction through superior service quality. The above mentioned MCDM techniques have been applied by the researchers on three major dimensions for assessing performance of banks and comparative analysis thereof. However, in this context, Datta Chaudhuri and Ghosh (2015) followed a different approach. They combined regulatory

perspectives, risk parameters and market perception while evaluating the performance of selected private sector and public sector banks in India by using a hybrid MCDM framework.

Table 1
MCDM techniques used in evaluating bank performance

MCDM Approaches	Author(s)
Data Envelopment Analysis (DEA)	De Young (1998); Kumar and Ravi (2007); Poghosyan and Cihak (2011); Halkos and Salamouris (2004); Kao and Liu (2004); Ho and Wu (2009); Avkiran (2010); Fallah et al. (2011); Dash and Charles (2012); Minh et al. (2013); Abbott et al. (2013); Grigoroudis et al. (2013); Marie et al. (2013); Doumpos and Zopounidis (2013); Dash and Vegesna (2014); Bayyurt (2013)
TOPSIS/ Fuzzy-TOPSIS	Wu et al. (2009); Pal and Choudhury (2009); Önder and Hepşen (2013); Amile et al. (2013); Amirzadeh and Shoorvarzi (2013); Toloie-Eshlaghy et al. (2011); Bayyurt (2013); Datta Chaudhuri and Ghosh (2015); Celen (2014); Momeni (2011); Akkoç and Vatansever (2013)
VIKOR	Datta Chaudhuri and Ghosh (2015); Momeni (2011);
ELECTRE	Datta Chaudhuri and Ghosh (2015); Bayyurt (2013);
AHP/ Fuzzy-AHP	Stankevičienė and Menkaitė (2012); Önder and Hepşen (2013); Albayrak and Erensal (2005); Wu et al. (2009); Chatterjee et al. (2010); Shaverdi et al. (2011); Celen (2014); Akkoç and Vatansever (2013)
COPRAS	Ginevičius and Podvieszko (2013)
SAW	Momeni (2011);
ANP	Dinçer et al. (2016)

In this study, we have adopted an integrated approach in assessing performance of selected public and private sector bank. We have applied Combinative Distance-based Assessment (CODAS) approach for understanding their comparative performance. As it is evident from table 1 that TOPSIS has been widely applied by the researchers. CODAS is a relatively new MCDM method, which considers the relative importance of distances from positive ideal solution (PIS) and negative ideal solution (NIS) unlike TOPSIS. We have used K-means clustering for grouping the banks based on their asset management efficiency specially NPA management. Finally, we have investigated whether better performance of banks lead to better standing in the market or not.

The rest of the paper is organized as follows. Section 2 discusses about the research methodology followed in this study while section 3 highlights the results of our analysis. In section 4, the findings are elaborated. Section 5 highlights some limitations and future scope of research. Finally, section 6 concludes the study.

2. Data and methodology

As it is mentioned in section 1, in this study we plan to assess the performance of the selected Indian public and private sector banks. The period of study is from financial year 2012-13 to financial year 2016-17, that is, 5 years. Broadly, this study aims to address the questions like: To what extent banks are different as far as performance is concerned? Are private banks superior in performance than their public sector counterparts? Are better performers efficient in recovering their advance, i.e. recovering NPAs? Does better financial performance reflect in market performance?

In order to address these questions, this study first presents a financial performance based ranking of the selected private and public sector banks using CODAS method. However, over the last few years, Non Performing Assets (NPA) have undermined the growth of the banking sector in India. Narasimham Committee II (1998) remarked,

“NPAs constitute a real economic cost to the nation is that they reflect the application of scarce capital & credit funds to unproductive uses. The money locked up in NPAs is not available for productive uses to the extent that bank seek to make provisions for NPAs or write them off. It is a charge on their profits, NPAs, in short, is not just a problem for banks; they are bad for the economy”. Financial ratios may not always give a true picture for two reasons: the banks are regulated by the policies set by the

Reserve Bank of India (RBI) and provisions for NPAs. Thus, in the second step, we have applied clustering method to check whether the banks are efficient enough to handle NPA. Our contention is that financially well performer is likely to belong to the efficient cluster. Thus, in this way we validate our MCDM based ranking. However, it is also likely that financially well performer is equally good at market measure. To check this proposition, we further have considered year wise price to book value (P/B ratio) for all the banks under study. The banks are ranked according to P/B ratio and get checked with financial performance based ranking. Also, their stock performance over last five financial year is analyzed. In essence, this study presents an integrated three-stage framework wherein the focus is put on checking financial performance, efficiency in handling NPA and market performance. Fig. 1 depicts the flow of the steps being followed in this study for analyzing bank performance.

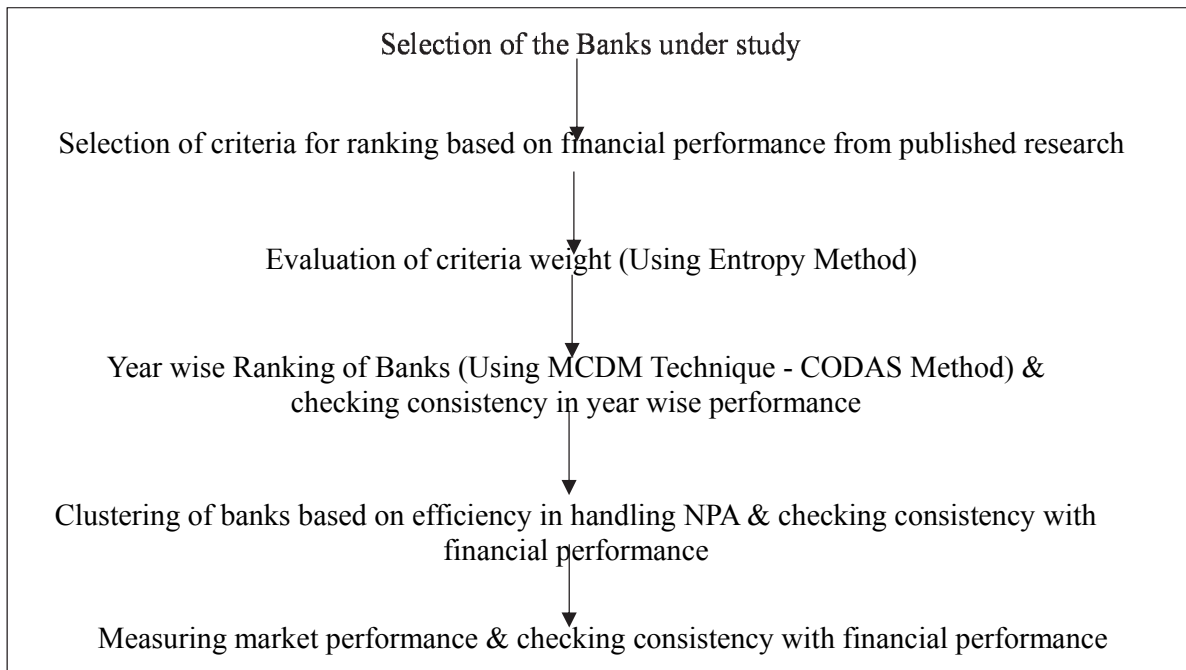


Fig. 1. Stepwise analysis scheme followed in this study (Source: Authors)

2.1. Sample

In order to select the banks under study, we considered both the sector: public and private, operating in India. On the basis of market capitalization (as reported by Moneycontrol, a leading financial information source in India), we have considered five leading banks from each category.

Table 2

Name of banks under study

Alternative Number	Name of the banks	Abbreviation	Sector
A1	HDFC Bank	HDFC	Private
A2	ICICI Bank	ICICI	Private
A3	Axis Bank	Axis	Private
A4	State Bank of India	SBI	Public
A5	Bank of Baroda	BOB	Public
A6	Canara Bank	CB	Public
A7	IndusInd Bank	IB	Private
A8	Kotak Mahindra Bank	KMB	Private
A9	IDBI Bank	IDBI	Public
A10	Punjab National Bank	PNB	Public

Table 2 lists the names of the banks selected under study. In this study data have been collected from secondary sources such as annual reports of the banks, financial statements and Basel Disclosures of

the banks, and websites like BSE, Moneycontrol, Valueresearchonline, Morningstar for the financial years 2012-13; 2013-14; 2014-15; 2015-16 and 2016-17.

2.2. Selection of Variables

Gowri and Malepati (2017) worked on management efficiency based ratios to compare public sector and private sector banks. In our study, for applying MCDM framework we have referred their study. However, Gowri and Malepati (2017) used gross profit to total assets and net profit to total assets ratios which in our study we have not considered. Due to some imposed regulations and nature of operations, banks need to maintain certain provisions. We contend that the above stated two ratios may not properly indicate management efficiency. Instead, we have used the ratio such as Profit before Provisions to Total Funds. Table 3 lists out the ratios which are used in this study as criteria for ranking the sample banks using MCDM technique.

Table 3
Criteria used for ranking sample banks using MCDM technique

Criterion	Description	Nature
C1	Profit Before Provisions / Total Funds	Higher the Better
C2	Interest Income to Total Assets Ratio	Higher the Better
C3	Net Interest Income (i.e. Interest earned-interest expended) to Total Assets	Higher the Better
C4	Other Income to TA	Higher the Better
C5	Interest Expended/TA	Lower the better
C6	Operating Expense/TA	Lower the better

Asset quality plays a central role in facilitating efficient banking operation and fostering sustainable growth. Asset quality acts as a good indicator of the nature of the debtors and the status of non-Performing Assets (NPA) as a percentage of the total assets. Of late, NPA has been a serious concern for the banking sector. NPA signifies credit risk since it reflects non-performance of recovery of loans and advances, and portfolio management. Presence of NPA affects effective recycling of funds; reduces income interest and decrease profit margin by including provisions. This leads to substantial weakening of capital base and in the long run loss of competitiveness. However, lending is an inevitable function of any bank. Thus, NPA is inherited in the system. The challenge lies in keeping the level of NPA below the affordable limit. There are several macro-economic and internal factors behind the generation of NPA. Internal factors like inefficient portfolio management, poor credit planning, assessment and monitoring, and lack of effective governance stand responsible for building up NPA levels beyond tolerable limits (Samir & Kamra, 2013). The presence of the NPA in percentage of gross and net advances moderates net worth performance. Efficiency in banking operations is reflected in managing NPA. Therefore, in our study, we have considered *mean gross NPA to total advance ratio* over the period of study as the basis of clustering. Accordingly, banks are classified under three categories: *efficient, average and poor* in relation to their NPA management efficiency. *Ceteris paribus*, lower value of this ratio indicates that the corresponding bank has an efficient NPA recovery process and effective management of the loan portfolio. In other words, loosely we can say management is efficient. Therefore, this clustering in a sense validates our findings of performance based ranking using CODAS method.

In order to understand the market performance of the banks under study, we have further considered Price to Book Value ratio (PB ratio). This ratio is broadly described as a ratio of price per share to book value per share over a defined period. Book value signifies how valuable a company is. There are umpteen research on analyzing PB ratio and its significance. Studies (Foster, 1970; Fairfield, 1994; Penman, 1996; Ohlson, 2001) reported that PB ratio or PB multiple is significantly associated with the future equity value i.e. in other words stock performance. Lower PB ratio value (especially below 1) signifies either the market opines the asset value is overstated, i.e. the stock is undervalued or, fundamentally there is something wrong with the company, i.e. return on asset (ROA) for the company is very poor (even negative). In essence, the higher PB ratio specifies acceptance of the respective company by the investors, i.e. a better market performance. In our study, we have ranked the banks

based on PB ratio year wise and subsequently checked its consistency with year wise financial performance based ranks. Further, we have considered 5 Yr. average PB ratio based ranking of the sample banks and checking its consistency with current PB ratio based rank. Since PB ratio is associated with stock performance, we have also carried out an analysis of stock price movements of the banks under study. Table 4 to Table 8 present year wise descriptive statistics of the banks based on performance parameters.

Table 4
Descriptive Statistics (Fy 2016-17)

Criteria		2016-17					
		C1	C2	C3	C4	C5	C6
Banks under study	A1	3.270000	0.060876	0.037000	0.014235	0.041867	0.022809
	A2	3.560000	0.051956	0.022000	0.025272	0.042005	0.019118
	A3	3.120000	0.055911	0.030000	0.019438	0.043974	0.020284
	A4	2.060000	0.044813	0.003000	0.013105	0.042003	0.017174
	A5	1.610000	0.042475	0.021000	0.009726	0.041283	0.013379
	A6	1.580000	0.052019	0.017000	0.012946	0.054010	0.014588
	A7	3.430000	0.066107	0.033936	0.023350	0.046701	0.026774
	A8	2.940000	0.063472	0.037868	0.016204	0.044610	0.026182
	A9	1.260000	0.054641	0.015899	0.010967	0.060922	0.014210
	A10	2.110000	0.047635	0.020814	0.012427	0.044817	0.013021

Table 5
Descriptive Statistics (Fy 2015-16)

Criteria		2015-16					
		C1	C2	C3	C4	C5	C6
Banks under study	A1	3.290000	0.063751	0.038000	0.015168	0.046032	0.023954
	A2	3.500000	0.054255	0.023000	0.021261	0.043729	0.017599
	A3	3.260000	0.057731	0.032000	0.017835	0.045969	0.019223
	A4	2.010000	0.051476	0.005000	0.012465	0.047278	0.018495
	A5	1.270000	0.046326	0.020000	0.007446	0.046653	0.013291
	A6	1.310000	0.058335	0.018000	0.008817	0.061955	0.013549
	A7	3.330000	0.068922	0.032248	0.023540	0.050437	0.026219
	A8	2.710000	0.065345	0.035891	0.013587	0.049328	0.028459
	A9	1.490000	0.055611	0.016265	0.009110	0.058642	0.011031
	A10	1.930000	0.052707	0.022943	0.010304	0.048117	0.014942

Table 6
Descriptive Statistics (Fy 2014-15)

Criteria		2014-15					
		C1	C2	C3	C4	C5	C6
Banks under study	A1	3.220000	0.063840	0.037000	0.015235	0.044156	0.023687
	A2	3.180000	0.055447	0.023000	0.018845	0.046510	0.017792
	A3	3.170000	0.056500	0.030000	0.018109	0.046012	0.019924
	A4	2.030000	0.055100	0.008000	0.011023	0.047548	0.018885
	A5	1.440000	0.045249	0.020000	0.006157	0.041646	0.010733
	A6	1.350000	0.059901	0.018000	0.008303	0.062201	0.013255
	A7	3.170000	0.073263	0.031345	0.022030	0.057477	0.024982
	A8	3.100000	0.070678	0.039842	0.019134	0.051844	0.030702
	A9	1.680000	0.058700	0.016144	0.011256	0.062933	0.011312
	A10	2.080000	0.058718	0.027440	0.009764	0.049326	0.017389

Table 7
Descriptive Statistics (Fy 2013-14)

Criteria		2013-14					
		C1	C2	C3	C4	C5	C6
Banks under study	A1	3.220000	0.065181	0.030000	0.016110	0.046080	0.024496
	A2	2.930000	0.053188	0.022000	0.017536	0.046587	0.017336
	A3	3.170000	0.057710	0.031000	0.019322	0.048767	0.020615
	A4	1.910000	0.057411	0.008000	0.010352	0.048581	0.019934
	A5	1.540000	0.044597	0.019000	0.006767	0.040901	0.010822
	A6	1.520000	0.059335	0.018000	0.007995	0.062211	0.012362
	A7	3.250000	0.077860	0.033217	0.021724	0.061623	0.025111
	A8	3.010000	0.076520	0.042473	0.015981	0.057625	0.029030
	A9	1.750000	0.061887	0.018303	0.009054	0.062542	0.010088
	A10	2.220000	0.059510	0.029334	0.008315	0.049194	0.016966

Table 7
Descriptive Statistics (Fy 2012-13)

Criteria		2012-13					
		C1	C2	C3	C4	C5	C6
Banks under study	A1	3.100000	0.067704	0.031000	0.017117	0.048094	0.028067
	A2	2.610000	0.051946	0.021000	0.015547	0.048825	0.016790
	A3	2.970000	0.056605	0.028000	0.019236	0.051434	0.020303
	A4	2.140000	0.058153	0.009000	0.010238	0.048093	0.018697
	A5	1.810000	0.049915	0.021000	0.006636	0.043648	0.010869
	A6	1.510000	0.060545	0.019000	0.007647	0.063537	0.012470
	A7	2.820000	0.077698	0.030459	0.018593	0.064801	0.023959
	A8	3.010000	0.073726	0.038302	0.013868	0.057792	0.026403
	A9	1.790000	0.061051	0.016647	0.009975	0.061007	0.009711
	A10	2.340000	0.067198	0.031024	0.008804	0.056459	0.017050

2.3. Methods

2.3.1. Determination of Criteria Weight – Entropy Method

The entropy method determines criteria weight based on relative information (Shannon, 1948). According to this method, higher the entropy value, more the criterion contains information. The steps (Li et al., 2011) are given below:

Suppose,

a_i : i^{th} alternative where $i = 1, 2, 3, \dots, m$

c_j : j^{th} criterion where $j = 1, 2, 3, \dots, n$

x_{ij} : j^{th} criterion value for the i^{th} alternative

Step1: Standardization of Criteria

This is done in order to eliminate the influence of criteria on the alternatives.

Standardized value of x_{ij} is given by:

$$r_{ij} = \begin{cases} \frac{x_{ij}}{\max_i x_{ij}} & i = 1, \dots, m; j = 1, \dots, n & \text{for beneficial criterion} \\ \frac{\min_i x_{ij}}{x_{ij}} & i = 1, \dots, m; j = 1, \dots, n & \text{for a non-beneficial criterion} \end{cases} \quad (1)$$

After this process, we get a standardized criteria matrix $R = [r_{ij}]_{m \times n}$

Step 2: Calculation of the criterion's entropy

Entropy of the j^{th} criterion is given by:

$$H_j = -\frac{\sum_{i=1}^m f_{ij} \ln f_{ij}}{\ln m}, i = 1, 2, \dots, m; j = 1, 2, \dots, n \quad (2)$$

where,

$$f_{ij} = \frac{r_{ij}}{\sum_i r_{ij}}, i = 1, 2, \dots, m; j = 1, 2, \dots, n \quad (3)$$

Step 3: Calculation of the criterion's entropy weight

Entropy weight of the j^{th} criterion is determined by:

$$w_j = \frac{1-H_j}{n-\sum_{j=1}^n H_j}, \text{ where } \sum_{j=1}^n w_j = 1 \quad (4)$$

2.3.2. Ranking of Banks - CODAS Method

Combinative distance-based assessment (CODAS) method is a relatively new MCDM technique. Unlike the TOPSIS method, a popular distance based MCDM technique, which has been used by many researchers; CODAS method incorporates the relative importance of distances from positive ideal solution (PIS) and negative ideal solution (NIS). Ghorabae et al. (2016) explained this method and presented its comparative analysis with other MCDM techniques. CODAS method evaluates the alternatives based on a combination of two distance measures such as the Euclidean (used as a primary measure related to l^2 -norm indifference space) and Taxicab distances (used as a secondary measure related to l^1 -norm indifference space) from the negative ideal solution (NIS). In this method if the Euclidean distances of the two alternatives are in proximity to each other (the degree of closeness is being controlled by a threshold parameter), comparison is carried out using the Taxicab distance. The alternative that has greater distances from NIS is considered best among the others. The steps are given below.

Suppose, there are 'm' alternatives and 'n' criteria. Hence, we have the decision matrix as $X=[x_{ij}]_{m \times n}$, where, x_{ij} : j^{th} criterion value for the i^{th} alternative. ($i = 1, 2, \dots, m; j = 1, 2, \dots, n$)

Step 1: Normalization of the decision matrix

Linear normalization of x_{ij} values are given by

$$r_{ij} = \begin{cases} \frac{x_{ij}}{\max_i x_{ij}} & \text{if } j \text{ is a beneficial criterion} \\ \frac{\min_i x_{ij}}{x_{ij}} & \text{if } j \text{ is a non-beneficial criterion} \end{cases} \quad (5)$$

Step 2: Formation of weighted normalized decision matrix

Weighted normalized decision matrix is given by

$$r_{ij}^* = w_j r_{ij}; \text{ where } w_j \text{ denotes the weight of the } j^{\text{th}} \text{ criterion. } (\sum_{j=1}^n w_j = 1) \quad (6)$$

Step 3: Determination of NIS

$$ns = [ns_j]_{1 \times n} \quad (7)$$

$$ns_j = \min_i r_{ij}^* \quad (8)$$

Step 4: Calculation of Euclidean (E_i) and Taxicab (T_i) distances of the alternatives from NIS

$$E_i = \sqrt{\sum_{j=1}^n (r_{ij}^* - ns_j)^2} \quad (9)$$

$$T_i = \sum_{j=1}^n |r_{ij}^* - ns_j| \quad (10)$$

Step 5: Construction of relative assessment matrix (R)

$$R = [h_{ik}]_{m \times m} \quad (11)$$

$$h_{ik} = (E_i - E_k) + (\psi(E_i - E_k) \times (T_i - T_k)) \quad (12)$$

where, $k = 1, 2, \dots, m$; ψ denotes a threshold function which indicates the equality of the Euclidean distances of two alternatives as

$$\psi(x) = 1, \text{ if } [x] \geq \tau; 0, \text{ otherwise} \quad (13)$$

x is the difference between Euclidean distances of the two alternatives and τ is a threshold parameter which determines the use of distance measure. In this study, we have taken its value as 0.02

Step 6: Calculation of assessment score (H_i) and ranking of alternatives

$$H_i = \sum_{k=1}^m h_{ik} \quad (14)$$

The alternative, which gets highest H_i would be ranked first and so on.

2.3.3. K-Means Clustering

Clustering is done in order to divide a set of data points into a specific number of disjoint groups. There are various methods of clustering. Standard k-Means Clustering or k-Means Clustering is a well-known method wherein the data points are partitioned into 'k' groups or clusters. The mechanism can be explained by following broad steps (Faber, 1994):

Steps:

- i. Calculation of k centroids
- ii. Distribution of data points to a particular cluster, where the data points are having least distance from the centroid of that group. For distance calculation, Euclidean distance is commonly used.
- iii. Repeat calculation of centroid of each cluster and distance of all data points from each such different centroid and reformation of clusters.
- iv. Each disjoint cluster is featured by its centroid and member data points or objects. Centroid of a cluster is a point from which sum of the distances of each member of that cluster is minimum. Repeat the process until the sum of distances from each object to its cluster centroid, over all clusters is minimized.

3. Results

For analysis purpose, we have used Microsoft Excel (2013 version) and IBM SPSS (version 20). Table 9 and 10 describes the results of determination of criteria weights using entropy method.

Table 9
Standardization Table (R-Matrix)

	C1	C2	C3	C4	C5	C6
A1	0.91854	0.92087	0.97707	0.56327	0.98604	0.57087
A2	1	0.78593	0.58096	1	0.98282	0.68108
A3	0.8764	0.84577	0.79222	0.76916	0.9388	0.64195
A4	0.57865	0.67789	0.07922	0.51855	0.98286	0.75817
A5	0.45225	0.64252	0.55455	0.38484	1	0.97327
A6	0.44382	0.78688	0.44892	0.51228	0.76436	0.89259
A7	0.96348	1	0.89616	0.92397	0.88398	0.48633
A8	0.82584	0.96014	1	0.64118	0.92543	0.49731
A9	0.35393	0.82654	0.41984	0.43397	0.67763	0.91631
A10	0.5927	0.72057	0.54965	0.49173	0.92115	1

(Source: Authors' own analysis)

Table 10
Criteria Weight

Criterion	C1	C2	C3	C4	C5	C6
H-value	0.9757	0.99587	0.95105	0.97925	0.99718	0.98631
Weight (w)	0.21196	0.03602	0.42698	0.18103	0.02464	0.11938

(Source: Authors' own analysis)

Table 11 shows year wise assessment score (Hi) and ranking of banks using CODAS method. Table 12 indicates year wise ranking of banks based on PB ratio.

Table 11
Year wise financial performance based ranking (CODAS method)

Bank	FY 2012-13		FY 2013-14		FY 2014-15		FY 2015-16		FY 2016-17	
	H	Rank	H	Rank	H	Rank	H	Rank	H	Rank
A1	4.09007	2	2.6948	3	3.7525	2	4.3181	1	3.8166	3
A2	-0.65165	6	-0.0801	5	0.4181	5	1.0546	5	1.2848	5
A3	2.16678	4	2.5018	4	2.0463	4	2.5919	4	2.1956	4
A4	-3.31892	7	-3.3819	7	-3.7377	7	-4.1903	9	-5.0150	10
A5	-3.36888	8	-3.8751	10	-3.8766	10	-3.2312	7	-2.4275	7
A6	-3.53637	9	-3.7081	9	-3.7652	8	-3.3579	8	-2.9439	8
A7	3.27015	3	4.1682	2	3.6790	3	4.3101	2	4.3575	1
A8	4.82363	1	5.6812	1	5.8067	1	4.0967	3	4.1705	2
A9	-3.99989	10	-3.6812	8	-3.8233	9	-3.9385	10	-3.4407	9
A10	0.52509	5	-0.3197	6	-0.4999	6	-1.6535	6	-1.9980	6

(Source: Authors' own analysis)

Table 12
Year wise ranking of banks based on PB ratio

Bank	Year wise Rank (Based on PB Ratio)					Current Rank	P/B ratio based rank 5 Years Avg
	2012-13	2013-14	2014-15	2015-16	2016-17		
A1	1	2	1	3	2	3	2
A2	4	5	5	5	5	5	5
A3	5	4	3	4	4	4	4
A4	6	6	6	6	6	7	6
A5	7	7	7	7	8	8	7
A6	9	9	10	10	10	9	10
A7	3	3	2	1	1	1	3
A8	2	1	4	2	3	2	1
A9	10	10	8	9	9	6	9
A10	8	8	9	8	7	10	8

(Source: Authors' own analysis)

Table 13 to Table 15 show the result of k-means cluster analysis using IBM SPSS 20.

Table 3
Initial Cluster Centers

	Cluster		
	1	2	3
Mean NPA ADV Ratio	.009579	.061855	.098771

(Source: Authors' own analysis)

Table 14
Cluster Membership

Case Number	Bank Name	Cluster	Distance
1	HDFC	1	.006
2	ICICI	2	.006
3	Axis	1	.007
4	SBI	2	.000
5	BOB	2	.005
6	CB	2	.001
7	IB	1	.006
8	KMB	1	.005
9	IDBI	3	.006
10	PNB	3	.006

(Source: Authors' own analysis)

Table 15
Final Cluster Centers

	Cluster		
	1	2	3
Mean NPA ADV Ratio	.015848	.056672	.092642

(Source: Authors' own analysis)

However, in order to check the statistical significance of the consistency between year wise performances based ranks; between performances based ranks and PB ratio based ranks, Spearman's Rank Correlation test has been performed. The correlation coefficient (Spearman's rho) is given by:

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2-1)},$$

where, d_i is the difference between ranks of two different methods for i^{th} alternative and n is the number of alternatives. We have performed this test using SPSS 20 software. Tables 16-19 exhibit the findings.

Table 16
Correlation between year to year financial performance based ranks

2012-13 & 2013-14	2013-14 & 2014-15	2014-15 & 2015-16	2015-16 & 2016-17
0.927	0.976	0.879	0.952
Significant at 0.01 level (2 tailed)	Significant at 0.01 level (2 tailed)	Significant at 0.01 level (2 tailed)	Significant at 0.01 level (2 tailed)

(Source: Authors' own analysis)

Table 17
Correlation between year wise performance based ranks & PB ratio based ranks

2012-13	2013-14	2014-15	2015-16	2016-17
0.891	0.879	0.782	0.855	0.855
Significant at 0.01 level (2 tailed)	Significant at 0.01 level (2 tailed)	Significant at 0.01 level (2 tailed)	Significant at 0.01 level (2 tailed)	Significant at 0.01 level (2 tailed)

(Source: Authors' own analysis)

Table 18

Correlation between year to year PB based ranks

2012-13 & 2013-14	2013-14 & 2014-15	2014-15 & 2015-16	2015-16 & 2016-17
0.976	0.891	0.927	0.976
Significant at 0.01 level (2 tailed)	Significant at 0.01 level (2 tailed)	Significant at 0.01 level (2 tailed)	Significant at 0.01 level (2 tailed)

(Source: Authors' own analysis)

Table 19

Correlation between PB ratio based current ranks & 5 years average ranks

Spearman's rho value	0.876	Significant at 0.01 level (2 tailed)
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(Source: Authors' own analysis)

Fig. 2 presents the comparison of stock performances of the banks under study.

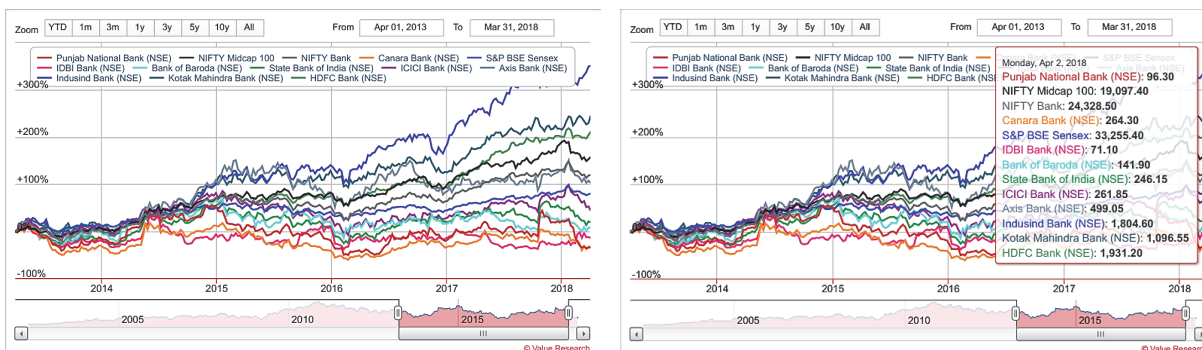


Fig. 2. The performance of the selected shares

Source: <https://www.moneycontrol.com>; retrieved on June 26, 2018

4. Discussion

This study lists out some significant observations. Firstly, we observe that year to year financial performance is consistent and statistically significant in nature (ref: Tables 16-18). We have noticed relatively high correlation values. It signifies that banks perform more or less in a similar manner during the period of study (2013-2017). However, Table 11 puts forth some interesting findings. We see private banks (A1-A3 and A7-A8) have performed relatively better than their public sector counterparts. IndusInd Bank, Kotak Mahindra Bank and HDFC bank consistently share top three positions while interestingly State Bank of India, IDBI bank and Bank of Baroda consistently remain at the bottom. This invokes a further level study. SBI being the leading public sector bank in India as per market capitalization does not perform well while getting compared with private sector players. In fact, its performance shows a decreasing trend. In order to check how the market has perceived these banks, we conducted a comparative study based on PB ratio. Here also we see better performance of the private banks than the public sector banks. Similar to their financial performances, IndusInd Bank, Kotak Mahindra Bank and HDFC bank consistently share top three positions while contrary to financial performance, SBI performs relatively better at market. This is probably because it had relatively better spread across the country and as per the consumer perception; it is a trustable PSU in the country. But, still its performance as compared to private sector banks under study is not satisfactory. Figure 2 and 3 also reveal the same fact that over a five year span, private sector banks have performed better than public sector banks as far as stock price movement is concerned. Next, when we perform K-means clustering to check the relative efficiency of the banks under study in managing their assets, specifically NPA; it reveals private sector banks are more efficient than public sector banks. Public sector banks mostly find their places in cluster 2 (Average) along with private bank while cluster 1 (Efficient)

consists of only private sector banks and cluster 3 (Poor) is constituted with only public sector banks. Therefore, our propositions before the study are supported by the findings.

5. Limitations and future scope of research

In this study, we have examined the performance of the selected private and public sector banks in India based on financial ratios related to management efficiency. Further, our sample size is relatively small. In a sense, this is a small scale study. In addition, we have only considered PB ratio as an indicator of market performance. Taking this study as a base level analysis, following scope of future research may be attempted. First, we have not considered other financial ratios pertaining to capital adequacy, asset management, earnings and liquidity positions. One can incorporate these ratios into analysis and study the banks on each such dimension for understanding their relative strength and weakness. Then, one study can be made to understand which factor is predominant in differentiating banks on the basis of financial performance. Second, a granular level investigation can be made to understand market perception about these stocks. For example, opinion based mining can be explored to reveal the key factors which control the market performance of the banks. Third, Indian banks are regulated by the central authority. Therefore, it is difficult to take customized measures. Hence, an exploratory study can be made to understand the nature of NPA and reasons behind their generation. In this context, assessing the impact of macro-economic variables can be thought of. Further, an empirical research can be carried out for investigating the impact of NPA on the operational efficiency of the bank. Fourth, in our study, we have not considered any non-financial measure. Therefore, a holistic attempt can be made considering the dimensions of balanced scorecard, service quality and service performance coupled with financial measures to understand which factors are really responsible for deciding the effective performance of the banks and according appropriate performance measurement approach can be derived thereof. Fifth, an integrated study can be made wherein the relationship between various factors affecting the performance of banks is examined and subsequently predictive analysis is carried out for forecasting future performance. Sixth, technology has invaded into banking operation significantly. An attempt can be made to assess banks' readiness to accept technological change and subsequent impact on their performance. Seventh, we have considered only Indian banks – Public Sector and Private Sector. However, foreign banks can also be included in the study to examine our findings. Further, we can make cross-country (e.g. Cross country study of performance of banks of SAARC countries) study over a relatively long time horizon (e.g. 10 years). A thought provoking study may be attempted to check consistency of financial and market performance and NPA growth over three distinct periods such as pre-recession (before 2008), during recession (2008-09) and post-recession (2010 till date). Finally, CODAS is a relatively advanced distance based MCDM method. We can further examine its applications in different management decision making situations. In addition, we can examine its applicability by using different other distance measures and/or different criteria weight determination techniques or different normalization approaches. Further, one can attempt to extend the application of this method in Neutrosophic Fuzzy environment. Also an attempt may be made to check its reliability by changing the value of the threshold parameter. The method like DEA can also be applied in conjunction with CODAS in various applications.

6. Conclusion

In this small scale study, we have attempted to appraise the performance of selected private sector and public sector banks in India on three dimensions: financial, market and management of NPA. We have also tried to examine that whether financially better performer can perform well in the market and whether efficient NPA management has any relationship with financial performance. We have applied MCDM technique such as CODAS for assessing financial performance based on mainly management efficiency ratios and k-means clustering for understanding and grouping the banks as per their NPA management. We have ranked the banks based on PB ratio, as an indicator of market performance. We have also examined stock price movements of the banks under study. Our findings conform to the proposition like the bank, which perform well financially, delivers efficient NPA management and gets

perceived well in the market place. Further, we have observed that private sector banks perform better than public sector banks on all three above mentioned dimensions. As per our understanding we have listed a few areas for future research based on our study. For development of the economy, banks play a very crucial role and over last few decades dynamic changes have been taking place in the global economy. Therefore, it is essential to study the performance of banks. Hence, we hope that our study shall add value to the growing literature.

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