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ANALYTICAL HIERARCHY PROCESS (AHP) BASED PORTFOLIO RANKING OF BOMBAY STOCK EXCHANGE (BSE)

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ABSTRACT

Selection of stock index is a crucial task in financial decision-making process specially when criterion are conflicting in nature. Multi criteria decision making (MCDM) techniques like AHP, CoCoSo etc. are the best method to solve these types of problems. The main aim of this research article is to use the application of Analytical Hierarchy Process (AHP) to rank the portfolios available in Bombay Stock Exchange (BSE). AHP is the best method to manage multiple criterion to produce best outcome. Three financial years data of ten indices of BSE with six criterion are considered in the ranking process. Experimental results reveal that BSE SENSEX index is performing consistently well for all three financial years.

Keywords: Multi Criteria Decision Making (MCDM), Analytical Hierarchy Process (AHP), Bombay Stock Exchange (BSE)

1. INTRODUCTION

To maximize the return for the investors, an ultimate policy for index selection is necessary to confront the demanding market competitions and fiercely competitive business environment. Financial professionals, investors, and other decision-makers may demand a stock index ranking. It is challenging to choose the best index, especially when the criteria are incompatible. In order to maximize profits while minimizing risk, researchers are constantly searching for the optimal solutions. One way to doing of an index selection problem with competing criteria is as a multicriteria decision maker. Analytical Hierarchy Process (AHP), Combined Compromise Solution (CoCoSo) etc. are some very popular methods for selection process. The concept of portfolio selection is initially introduced by Markowitz (1952) where a mean variance model is applied for selection process. Multiple author have applied the application of AHP for selecting object with conflicting criterion. Buyukozkan et al. (2012) have applied the AHP for electronic service quality in healthcare industry. Different authors (Bevilacqua et al., 2004 ; Chou et al., 2012, Hwang, 1981) has applied application of AHP for human resource and optimization. This research is inspired by Hota et al. (2014; 2015; 2016; 2017) in which the author used the AHP

method in financial domain and the solution teachers section problems. Durán et al.(2011) and Fishburn et al.(1967) has applied fuzzy AHP in engineering domain for object ranking.

In this research article we have applied the application and strength of AHP method to manage the conflicting criterion of portfolio and obtained the result of as ranking of portfolio. In this paper we evaluate the criterion weights by evaluating relative importance matrix defined in AHP. This is the best and logical way to define the priorities of give criterion that will help to find the rank of objects and will help indecision making. Ten indexes with six criteria, spanning three financial years (2023–24, 2022–23, and 2021–22), are taken into consideration during the selection process.

2. PROPOSED WORKFLOW

Figure 1 displays a workflow that explains the entire process of using AHP and its integrated technique for stock index ranking. More information is provided below for each element of the work flow diagram:

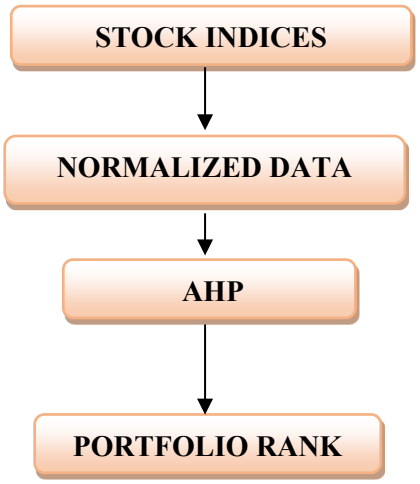

Figure 1 Workflow of Research Work

2.1. STOCK INDICES

For experimental purposes, stock index data is downloaded from www.bseindia.com. The ten well-known BSE (Bombay Stock Exchange) indices that we have taken into consideration are the BSE SENSEX, BSE GREENEX, BSE CARBONEX, BSE AUTO, BANKEX, BSE ENERGY, BSE HEALTHCARE, BSE IT, BSE POWER AND BSE GAS AND OIL. For each of these indices, we have six criteria: High (C1), Low (C2), Close (C3), P/E ratio (C4), P/B ratio (C5), and Dividend (C6).

2.2. AHP METHOD

An approach to decision making that involves categorizing multiple choice criteria into a hierarchy, evaluating the relative importance of these criteria, comparing alternatives for each criterion, and arriving at an overall ranking of the alternatives is the Analytic Hierarchy Process (AHP), which was first proposed by Satty (2001) and is one of the most widely used MCDM techniques for complex decision-making problems.

The radical root approach, sometimes known as the geometric mean method, is used in the general AHP process and goes like this (Nasoli 2012, Hota et al. 2015):

Step 1: Determine the objective with alternative and criteria.

Step 2: Now we prepared a normalized object data for the portfolio ranking. For this we divides all value of a column with max value of that column. Let A is a column now calculation is done through following formula-

$$A_i=(A_i/\max(A)) \quad (1)$$

Here i^{th}value is divided by the maximum value of corresponding column for normalized value

Step 3: Now construct a pair-wise comparison matrix using a scale of relative importance [10]. The judgments are entered using the fundamental scale of the analytic hierarchy process. An attribute compared with it is always assigned

the value "1", so the main diagonal entries of the pair-wise comparison matrix are all "1" and the rating is based on Saaty's nine-point scale. Assuming M attributes, the pair–wise comparison of attribute i with attribute j yields a square matrix $B_{M\times M}$where a_{ij}denotes the comparative importance of attribute i with respect to attribute j, this matrix is represented as A1. In the matrix b_{ij}=1 when i=j and

$$b_{ji}=\frac{1}{b_{ij}}$$

Find the relative normalized weight (Wj) of each attribute by

(i) Calculating the geometric mean of the i^{th} row, and

(ii) Normalizing the geometric means of rows in the comparison matrix. This can be represented as:

$$GM_j = \left[\prod_{i=1}^{M} b_{ij}\right]^{1/M} \quad (2)$$

$$\text{and } W_j = GM_j \Big/ \sum_{i=1}^{M} GM_j$$

Calculate matrices E1 and E2 such that E1(A3) =A1*A2 and E2= A3/A2, where A2=[w1,w2,……..,wi]$^{T.}$

Determine the maximum Eigen value λ_{max}that is the average of matrix A4. Calculate the consistency index

$$CI=(\lambda_{max}-M)\Big/(M-1) \quad (3)$$

Obtain the random index (RI) for the number of attributes used in decision making [11]. Calculate the consistency ratio

$$CR=CI/RI \quad (4)$$

Step 4: In this step, we need to obtain the overall or composite performance scores for the alternatives by multiplying the relative normalized weight (Wj) of each attribute (obtained in step two) with its corresponding normalized object data for each alternative and summing over the attributes for each alternative (Row, 2010).

3. EXPERIMENTAL WORK

3.1. STOCK INDEX

The experiment's portfolio data was collected from the BSE financial website, www.bseindia.com. The earliest and fastest stock exchange in Asia, the BSE was founded in 1875, and it has contributed to the expansion of the Indian corporate sector by giving it a reliable platform for obtaining finance. The BSE system's procedures are also intended to protect the integrity of the market, promote the expansion of the Indian capital market, and foster intense competition in every market niche. BSE SENSEX, BSE GREENEX, BSE CARBONEX, BSE AUTO, BANKEX, BSE ENERGY, BSE HEALTHCARE, BSE IT, BSE POWER AND BSE GAS AND OIL well-known BSE stock indices are available. Table 1 shows the data that was retrieved from the BSE website for the ten stock indexes for the years 2023–2024. The table include all six criterion that are conflicting in nature. For the portfolio ranking it is important to define the priorities of certain criterion. This will be done by defining weights of each criterion with analytical process that is defined in next step.

Table 1 Stock Index Data of Year 2023-24

S.N.	Name of Portfolio	Criteria					
		High	Low	Close	P/E ratio	P/B ratio	Dividend
1	BSE SENSEX	63583.07	50921.22	58991.52	22.91	3.32	1.2
2	Greenex	4976.16	3920.67	4342.6	26.86	3.55	0.89
3	Carbonex	3123.36	2505.33	2870.46	21.84	3.16	1.42
4	AUTO	31002.41	23022.61	28246.92	65.57	4.27	1.05

5	BANKEX	50164.43	37242.74	46031.95	17.94	2.35	0.62
6	Energy	9058.39	7268.42	7448.86	11.37	1.71	3.49
7	Healthcare	25129.65	20847.55	21883.5	36.62	4.04	0.68
8	IT	36902.89	26742.69	28478.99	26.24	6.48	1.98
9	Power	5352.94	3235.62	3605.8	20.46	2.88	2.02
10	Gas and Oil	21198.44	16378.92	17383.4	11.41	1.45	4.04

3.2. DATA NORMALIZATION

Equation 1 is used to produce the normalized BSE data for ten portfolios with six distinct criteria for the financial year 2023–2024. The results are displayed in Table 2. This is the first 10*6 matrix that may be used with the AHP technique. For the purpose of demonstrating and making clear how to apply the AHP approach for portfolio selection and ranking, just one financial year's worth of data is utilized in the study. However, AHP may be applied similarly for the remaining two financial years.

Table 2 Normalized Portfolio Data Applied with AHP with Six Portfolios and Six Attributes (Criteria)

S.N.	Name of Portfolio	Criteria					
		High	Low	Close	P/E ratio	P/B ratio	Dividend
1	BSE SENSEX	1.000	1.000	1.000	0.349	0.512	0.297
2	BSE GREENEX	0.078	0.077	0.074	0.410	0.548	0.220
3	BSE CARBONEX	0.049	0.049	0.049	0.333	0.488	0.351
4	BSE AUTO	0.488	0.452	0.479	1.000	0.659	0.260
5	BSE BANKEX	0.789	0.731	0.780	0.274	0.363	0.153
6	BSE Energy	0.142	0.143	0.126	0.173	0.264	0.864
7	BSE Healthcare	0.395	0.409	0.371	0.558	0.623	0.168
8	BSE IT	0.580	0.525	0.483	0.400	1.000	0.490
9	BSE Power	0.084	0.064	0.061	0.312	0.444	0.500
10	BSE Gas and Oil	0.333	0.322	0.295	0.174	0.224	1.000

3.3. STOCK INDEX RANKING USING AHP METHOD

A relative importance matrix as shown in Table 3 is constructed using Saaty's 9 point scale (2001) and based on the experience of financial experts. As per requirement, value of each attribute (Aij) is assigned. Some of the investor selects a portfolio based on higher value of P/E ratio and dividend then the other criteria. In the Table 2, High is more important than Low in portfolio selection problem, so a relative importance value of 5 (A_{12} =5) is assigned to High (C1) over Low (C2) and a relative importance value 1/5= 0.2 is assigned to Low (C2) over High (C1). Similarly other values in the matrix are assigned based on the expert judgment. In the matrix A_{ij} =1 for i=j, means when a criterion is compared with itself, relative importance value will be always 1. Now using equation 2, 3 and 4 respectively geometric mean, consistency index (CI) and consistency ratio (CR) are calculated and presented in the same table (Table 3). The basic aim of the weighted matrix is to calculate the value of CR which should be less than 0.1 which proves good consistency in the judgements made by the experts. As per calculation the value of CR is 0.099 which is less than 0.1, hence the weights assigned by the expert are consistent and can be used in the selection process to obtain final rank of portfolios.

Table 3 Relative importance matrix (pair-wise comparison: Criteria to Criteria)

Aij	C1	C2	C3	C4	C5	C6	GM	Relative Normalized Weight (W=A2)	E1(A3)= A1*A2	E2= A3/A2	λ_{max}	CI	CR

C1	1	5	3	5	3	5	3.22	0.42	2.70	6.42	6.62	0.12	0.099
C2	0.2	1	0.33	1	1	1	0.63	0.08	0.51	6.18			
C3	0.33	3	1	3	3	3	1.73	0.22	1.42	6.32			
C4	0.2	1	0.33	1	5	3	1	0.13	0.96	7.36			
C5	0.33	1	0.33	0.2	1	3	0.63	0.08	0.58	6.98			
C6	0.2	1	0.33	0.33	0.33	1	0.44	0.05	0.37	6.44			
							7.67						

Once the weights are proved to be consistent, AHP is further applied as explained in the previous section to find out rank of portfolios as shown in Table 4.

Table 4 Obtained Rank Using AHP for the Financial Year 2023-24

S.No.	Portfolio	Weight value	Rank
1	BSE SENSEX	0.821	1st
2	BSE GREENEX	0.163	8th
3	BSE CARBONEX	0.135	10th
4	BSE AUTO	0.542	4th
5	BSE BANKEX	0.634	2nd
6	BSE ENERGY	0.186	7th
7	BSE HEALTHCARE	0.411	5th
8	BSE IT	0.548	3rd
9	BSE POWER	0.155	9th
10	BSE GAS AND OIL	0.321	6th

The entire process as explained above is applied for stock portfolio data of the financial year 2022-2023 and 2021-2022 and obtained rank of portfolios are presented in Table 5.

Table 5 Obtained Rank Using AHP for the Financial Years 2023-24 and 2021-22

S.No.	Portfolio	Financial Year 2022-23		Financial Year 2021-22	
		Weight	Ranks	Weight	Ranks
1	BSE SENSEX	0.701	1st	0.40403	1st
2	BSE GREENEX	0.043	8th	0.20724	8th
3	BSE CARBONEX	0.015	10th	0.13222	10th
4	BSE AUTO	0.422	4th	0.36014	3rd
5	BSE BANKEX	0.514	2nd	0.30151	4th
6	BSE ENERGY	0.066	7th	0.20537	9th
7	BSE HEALTHCARE	0.291	5th	0.29667	5th
8	BSE IT	0.428	3rd	0.3718	2nd
9	BSE POWER	0.035	9th	0.20999	7th
10	BSE GAS AND OIL	0.201	6th	0.24563	6th

The rank of the portfolio of three consecutive financial years may be compared to check the consistent performance of the portfolios over the years for decision making process, rank of these three financial years is presented in Table 6, from which it is clear that S&P BSE SENSEX is continuously performing well by holding first rank in all three years.

Table 6 Year Wise Comparison of Portfolios

S.No.	Portfolio	Financial Year 2023-24	Financial Year 2022-23	Financial Year 2021-22
		Ranks	Ranks	Ranks
1	BSE SENSEX	1st	1st	1st
2	BSE GREENEX	8th	8th	8th
3	BSE CARBONEX	10th	10th	10th
4	BSE AUTO	4th	4th	3rd
5	BSE BANKEX	2nd	2nd	4th
6	BSE ENERGY	7th	7th	9th
7	BSE HEALTHCARE	5th	5th	5th
8	BSE IT	3rd	3rd	2nd
9	BSE POWER	9th	9th	7th
10	BSE GAS AND OIL	6th	6th	6th

The graphical representation of the performance of the BSE portfolio also presented in figure 2. It is clear from the figure that BSE SENSEX is dominating in all three years and be the best portfolio for the investment (Sharma et al., 2022).

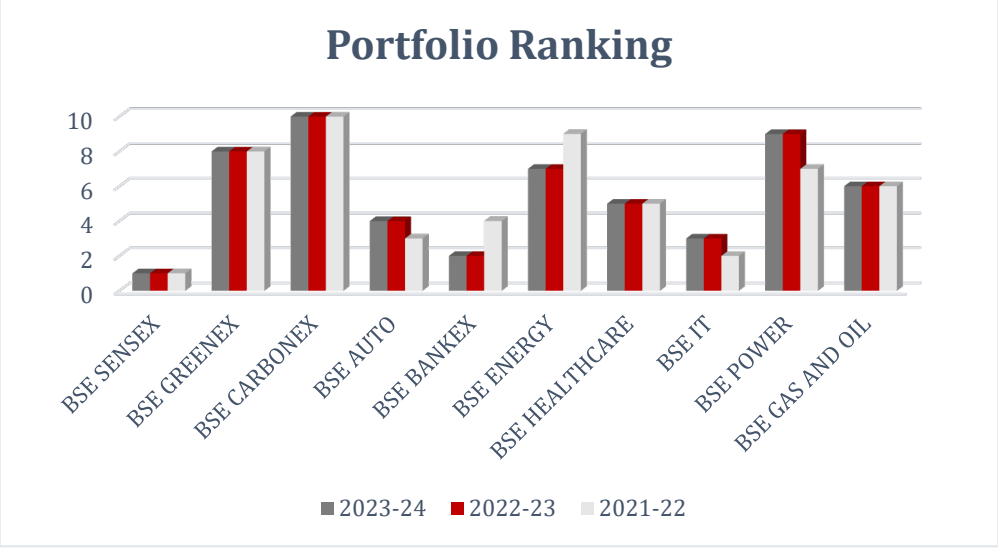

Figure 2 Comparative Analysis of Portfolio Raking

4. CONCLUSION

Selection of an object from multiple ones are not easy when indicators related with those objects are equally important. Selection of best portfolio is the same task due to their conflicting nature of criterion. In this paper we have applied MCDM technique i.e. AHP that is the best one method to deal with. We have applied taken ten different portfolios data of three consecutive years from BSE to find the best one. After using the mathematical analysing described in AHP we found that BSE SENSEX is in top ranking for all three continuous years.

CONFLICT OF INTERESTS

None .

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