

EXPERT PORTFOLIO SYSTEM USING INTEGRATED MCDM-GP APPROACH

H.S. Hota, Bilaspur University, India (proffhota@gmail.com)
Sanjay Kumar Singhai, Govt. Engineering College, India (ersanjaysinghai@gmail.com)
Vineet Kumar Awasthi, Dr. C. V. Raman University, India (vineet99kumar@gmail.com)

ABSTRACT

Fund diversification in expert manner is a challenging task for fund manager as well for the investor with expected high return and minimum risk. This paper investigates an integrated approach of Multiple Criteria Decision Making (MCDM) and Goal Programming (GP) methods where many MCDM methods were used to rank stock indices chosen for the experiment and then GP was applied for the diversification of fund in highest ranked BSE30 Index. The high return and minimum risk along with few other constraints were set by the decision maker before applying GP. Experimental result of integrated approach of MCDM and GP has achieved up to the level of defined expected return and risk and shows the best diversification of fund in all 30 stocks of BSE30 Index.

Keywords: Goal Programming (GP), Multi Criteria Decision Making (MCDM), Fund diversification.

INTRODUCTION AND RELATED WORK

Diversification of fund to be invested in the stock market is the most challenging task for the fund manager as well as for the investor and to handle the risk and return up to the expectation. The major objective of this piece of research work is to achieve good return with manageable risk. There are various measures of risk associated with fund diversification and as a result it can be really difficult to determine how it can be allocated for the best return with minimum risk. An expected value variance model for portfolio optimization was introduced by Markowitz (1952), based on two factors: risk and return. These two factors are common to all the investors, but in practical there are some common factors which affects the assets with a great deal. Identification of these factors are very difficult and challenging, therefore a goal should be determined and focused to identify the most important factors for the fund diversification. A stock portfolio problem can be viewed as a Goal Programming (GP) model with two objectives: risk and return. GP is first introduced by Charnes et al. (1955) and Charnes et al. (1961) and then later extended by Ijiri (1976), Lee (1965) and Ignizio (1972). The main idea behind this model is the determination of the aspiration levels of an objective function and the minimization of any (positive or negative) deviations from these levels.

Jadidi et al. (2015) proposed multi choice GP used for supplier selection using weighted GP and used successfully for fund allocation. The uncertainty is reduced by the robust optimization to increase the chances to achieve the feasible solution. Authors (Ghahtaran et al., 2013) use a multiple objective approach of GP to investigate the use of factors for portfolio selection of international mutual funds. They applies different GP models selection that characterized by simplicity of form and practicality of approach. GP models are widely used for the financial portfolio selection problems (Tamiz et al., 2013; Belaid et al., 2014). Authors (Choudhary et al., 2014) propose a multi-objective integer linear programming model for joint decision making of inventory, supplier selection and carrier selection problem. In this research net rejected items, net costs and net late delivered items are considered as three objectives that have to be minimized. A GP model is also applied to check the financial performance of a bank of Malaysia (Halima et al., 2015). To examine the performance of a bank 6 goals (asset accumulation, liability reduction, equity wealth, earning, profitability and optimum management) have been checked. The result set the guideline for the financial institution to develop strategies to deal with different economical seniors. Authors (Jadidi et al., 2014) use the GP for supplier selection and order allocation and deals with three objectives to minimization of price, rejects and lead-time. Sharma et al. (2013) suggests a Decision Support System (DSS) to the investor to take optimal investment decisions using GP, based on constraints. On the other hand Multi Criteria Decision Making (MCDM) methods like Analytical Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Simple Additive Weighting (SAW) methods and its combination were also applied for ranking of stocks and index.

Sevastjanov et al. (2009) presents a new approach using MCDM for the stock ranking and optimization. For this analysis two general criteria are used where first one is based on the financial indices and second is the two-criterion performance of firm based on the stock prices. Authors use AHP method for the ranking of stock and also for the selection of “good” stock. Hota et al. (2016) in their recent work utilizes integrated of AHP-TOPSIS and AHP-SAW methods to find out rank of 6 stock indices with 6 different criteria and found BSE 30 index as one of the best index.

To the best of our knowledge, MCDM and GP methods were not combines by any of the authors at least in the domain of stock portfolio management and it is assumed that a good combination of these two techniques: MCDM and GP may improve the result and may produce high return with low risk. This research work is an extension of the work of (Sharma et al., 2013) with respect to goal and constraints decided by the authors and the work of (Hota et al., 2016) with respect to the ranks obtained using various MCDM methods with the latest data of financial year 2016-17. An integrated approach of both MCDM and GP as MCDM-GP has achieved expected level of return with minimum risk in terms of beta value and standard deviation.

PORTFOLIO SYSTEM

Entire process to develop an expert portfolio system, carried out in this research work is depicted in Figure 1 and divided into two steps as below:

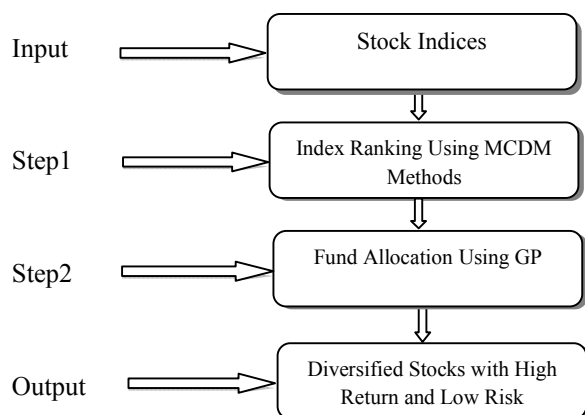


Figure 1: Portfolio Management using MCDM-GP Approach

Step 1: Index Ranking

Six indices S&P BSE SENSEX (BSE 30), S&P BSE BENKEX, S&P BSE GREENEX, S&P BSE CARBONEX, S&P BSE AUTO, S&P BSE 100 with six criterion High (C1), Low (C2), Close (C3), P/E ratio (C4), P/B ratio (C5) and Dividend (C6) were considered to find out the best index using MCDM methods in combination of AHP, TOPSIS and SAW. AHP is a MCDM method introduced by Satty (2001) widely used in decision making with conflicting criteria. The basic advantages of this technique are to find the rank of the alternatives using comparing alternative for each criteria. In this method data is normalized, then a pair wise comparison matrix is prepared with M attributes which is a square matrix. A pair wise comparison matrix is then constructed whose elements denotes the comparative importance between attributes. In the pair wise comparison matrix geometric mean, relative normalized weight (W), consistency index (CI) and consistency ratio (CR) are calculated where CR should be less than 0.1. When the weights are consistent then composite performance score is calculated to find the rank of stock index (Hota et al., 2016). AHP can be integrated with other alternative MCDM methods like TOPSIS and SAW where AHP calculates weights and other MCDM methods find out ranks. TOPSIS is another method which find out weights of the alternatives using positive and negative ideal solutions on the other hand SAW is simple ranking based optimization method which uses the weight for the different criteria to obtain the weighted score for each alternative using normalized decision matrix. This research work combines AHP with TOPSIS and SAW as AHP-TOPSIS and AHP-SAW.

Step2: Portfolio Management

As a second step fund allocation in the portfolio was done using GP with top ranked index. The GP model aggregates multiple objectives and allows obtaining the portfolio where the deviations between achievement and the aspirations levels of the attributes are to be minimized. There are four types of GP found in the literature, out of which Lexicographic Goal Programming (LGP) is quite useful to solve the problems in financial planning because financial criteria can be easily expressed in term of goals. A general format of LGP (Sharma et al., 2013) model is:

$$\text{Minimize} [P_1(\bar{d}), \dots, P_k(\bar{d}), \dots, P_K(\bar{d})], \quad (1)$$

Subject to,

$$f_i(Z) + d_i^- - d_i^+ = b_i, \quad i = 1, 2, 3, \dots, J \quad (2)$$

$$d_i^-, d_i^+, x \geq 0 \text{ and } d_i^-, d_i^+ = 0 \quad (3)$$

Where $P_k(\bar{d}) = P_k(w_{ik}^- d_{ik}^- + w_{ik}^+ d_{ik}^+)$ and P_k is the k^{th} priority structure, w_{ik}^- and w_{ik}^+ are the numerical weights associated with the deviational variables d_{ik}^- and d_{ik}^+ respectively at the priority level P_k , \bar{d} is the vector of decision variables, $f_i(Z)$ is the i^{th} goal constraint, d_{ik}^- and d_{ik}^+ represents negative and positive deviation variables respectively. The goals and constraints are set by the decision maker to determine the optimum solution. This is achieved by minimizing a weighted sum of deviations from target goal.

Designing of LGP model for portfolio management, following notifications are used:

1) **Goal:** Goals of decision makers are defined as follows:

- i. Utilizing total available funds for investment within specified constraints.
- ii. Maximize the portfolio's expected annual return set by the investor.
- iii. Minimize the portfolio's risk (Beta and Standard Deviation) as much as possible.

2) **Constraint:** Following constraints as decided by D. K. Sharma and et al. (2013) are considered for portfolio management to diversify fund:-

i) **Investments:** One of the important aims is to invest maximum amount of fund from total available fund (F) into all the stocks. The constraint is:

$$\sum_{i=1}^J Z_i + d_1^- - d_1^+ = F \quad (4)$$

ii) **Annual return:** The main objective is to maximize the total return of selected stock portfolio is high return value. If the total return is A then constrain is defined as:

$$\sum_{i=1}^J A_i Z_i + d_2^- - d_2^+ = A \quad (5)$$

Risk: Two types of risk are as follows:

➤ **Beta:** Beta (B) is the measurement of the sensitivity of a security's returns to market returns. The constraint for composite B of the portfolio is presented as follows:

$$\sum_{i=1}^J B_i Z_i + d_3^- - d_3^+ = B_a \quad (6)$$

Where β_j is the measure of risk associated with stock j. ($j=1, 2, \dots, J$) and β_a is an acceptable level of beta.

➤ **Standard Deviation:** The diversification in standard deviation of portfolio reflects in its systematic risk. The aim of the decision maker is to limit the value of standard deviation to a certain level. The goal constrain for composite standard deviation (σ) is as follows:

$$\sum_{i=1}^J \sigma_i Z_i + d_4^- - d_4^+ = \sigma_a F \quad (7)$$

Where σ_j is the measure of non systematic risk associated with stock j ($=1, 2, \dots, J$) and σ_a is an acceptable level of standard deviation.

iv) **Minimum and Maximum Limits:** These limits are as follows:

➤ **Maximum Limit:** It is also important that not more than a certain percentage (y) of total funds (F) is invested in a single stock. The maximum limit investment constraint is as follows:

$$Z_i + d_5^- - d_5^+ = y * F, \quad i = 1, 2, 3, \dots, J \quad (8)$$

➤ **Minimum Limit:** A well diversified fund allocation is possible when all the stock must have some of the minimum fund percentage (M). The constraint for minimum investment is as follows:

$$Z_i + d_6^- - d_6^+ = M * F, \quad i = 1, 2, 3, \dots, J \quad (9)$$

EXPERIMENTAL STUDY

Experiment was done using LINGO software for simulation of GP. Various MCDM methods were applied first to find out ranks of indices considered for the research and then GP was applied to diversify the fund in various stocks of selected index with expected rate of return and risk. As stated above entire process was carried out in two different steps as below:

Step 1

The integrated method of AHP-TOPSIS and AHP-SAW are applied for stock index data of six BSE related indices of financial year 2016-17 downloaded from financial site www.bseindia.com with 6 different criteria as explained above. AHP was used first to calculate weights of indices and then these weights were utilized to find out ranks of indices using TOPSIS and SAW methods. Consistency ratio (CR) was calculated and found less than 0.1, also weights were calculated and presented in Table 1. Finally rank of each alternative (Index) was calculated and presented in Table 2. Both the methods are ranking indices in same order with S & P BSE SENSEX as best index with weight value of 0.940 and 0.947 respectively for AHP-TOPSIS and AHP-SAW.

C1	C2	C3	C4	C5	C6
0.420	0.082	0.225	0.130	0.082	0.057

Index	AHP-TOPSIS		AHP-SAW	
	Weighted Score	Rank	Weighted Score	Rank
S&P BSE SENSEX	0.940	1	0.947	1
S&P BSE BANKEX	0.313	3	0.782	3
S&P BSE GREENEX	0.056	5	0.296	5
S&P BSE CARBONEX	0.030	6	0.261	6
S&P BSE AUTO	0.716	2	0.784	2
S&P BSE 100	0.269	4	0.486	4

Step 2

S & P BSE SENSEX is the top ranked index as identified in Step1, this index consist 30 stocks downloaded from www.bseindia.com with open, high, low, close etc. Out of which high, low, close were used to derive new variables as yearly return, beta value and standard deviation to be used in GP. In order to get high return from these stocks in expertise manner LGP was used. LGP is one of the best alternative which can optimize fund in such a manner so that high return with low risk may be achieved. Goals and constraints as stated in section II were used to apply GP. The minimum beta value and standard deviation is set by the decision maker are 0.888 and 2.1% respectively. The minimum and the maximum investment in each stock is 1% and 10% of total fund respectively.

Constraints for portfolio management problem are formulated as follows using equation 1 to 9 as below:

I. Constraints

1) The goal constraint for total investment (F) in various stocks can be written as follow using equation 4:

$$\sum_{i=1}^{30} Z_i + d_1^- - d_1^+ = 1$$

2)The goal constraint for one year return (A) from investment can be expressed as follow using equation 5:

$$\sum_{i=1}^{30} A_i Z_i + d_2^- - d_2^+ = A$$

3)The goal constraint for the portfolio’s beta can be expressed as follow using equation 6:

$$\sum_{i=1}^{30} B_i Z_i + d_3^- - d_3^+ = 0.8882$$

4) The goal constraint for standard deviation can be expressed as follow using equation 7:

$$\sum_{i=1}^{30} \sigma_i Z_i + d_4^- - d_4^+ = 0,0214$$

5) The upper limit for investment in each stock can be expressed as follow using equation 8:

$$Z_i + d_{i+4}^- - d_{i+4}^+ = 0.10 \quad , i = 1,2,3 \dots\dots\dots 30$$

6) The lower limit for initial investment (M) in each stock can be expressed as follow using equation 9:

$$Z_i + d_{i+34}^- - d_{i+34}^+ = 0.01 \quad , i = 1,2,3 \dots\dots\dots 30$$

II. Priority Structure

The priority structure of LGP is shown in Table3 (Sharma et al., 2005). The priority of goal is used to provide some importance to a certain goal. If more than one goal is seems to be equally important then all goals are held in same priority level. The priority of any goal is a process of assigning some weight to each priority that identifies the importance of any goal. In our study we set priority level same for all the priorities to check the performance of our expert portfolio system.

Table 3: Priorities of Goals		
Priority	Description	Deviations
P1	Utilize available funds and satisfy restrictions on Investment	$[w_1^+ d_1^+ + w_1^- d_1^- + w_{j+4}^+ d_{j+4}^+ + w_{j+34}^- d_{j+34}^-]_{j=1, \dots, 30}$
P2	Maximize the portfolio’s expected annual return	$w_2^- d_2^-$
P3	Minimize the portfolio’s risk (Beta and Standard Deviation)	$w_3^+ d_3^+ + w_4^+ d_4^+$

RESULT ANALYSIS

In order to validate and to check the robustness of developed expert portfolio system 3 priorities and 3 different cases with 3 different expected annual returns as investor recommendation were considered. Fund is diversified in all 30 stocks ($Z_1, Z_2, \dots\dots Z_{30}$) with referred minimum risk and set beta value and standard deviation to find out best feasible solution. The findings of goal for all 3 cases are illustrated below:

Case 1: If expected return is 20% of total investment from the investor’s choice then fund diversification of total fund done by LGP is shown in Table 4. LGP allocated 100% fund with objective function=0, calculated annual return=0.20(20%), beta value= 0.888 and standard deviation= 0.016 (1.6%). LGP has achieved highest return with minimum risk.

Table 4															
Stock	Z ₁	Z ₂	Z ₃	Z ₄	Z ₅	Z ₆	Z ₇	Z ₈	Z ₉	Z ₁₀	Z ₁₁	Z ₁₂	Z ₁₃	Z ₁₄	Z ₁₅
2016	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.028	0.01	0.01	0.01	0.01	0.1
Stock	Z ₁₆	Z ₁₇	Z ₁₈	Z ₁₉	Z ₂₀	Z ₂₁	Z ₂₂	Z ₂₃	Z ₂₄	Z ₂₅	Z ₂₆	Z ₂₇	Z ₂₈	Z ₂₉	Z ₃₀
2016	0.01	0.01	0.1	0.01	0.01	0.1	0.01	0.1	0.01	0.1	0.1	0.08	0.01	0.07	0.01

Case 2: If expected return is 30% of total investment from the investor’s choice then fund diversification of total fund done by LGP is shown in Table 5. LGP invested 100% fund with objective function value = 0.105, calculated annual return=0.295(29.5%), beta value= 0.852 and standard deviation= 0.016 (1.6%). In this case LGP is lacking return with 0.5% and achieved 29.5% return with minimum risk level.

Stock	Z ₁	Z ₂	Z ₃	Z ₄	Z ₅	Z ₆	Z ₇	Z ₈	Z ₉	Z ₁₀	Z ₁₁	Z ₁₂	Z ₁₃	Z ₁₄	Z ₁₅
2016	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.01	0.01	0.01	0.01
Stock	Z ₁₆	Z ₁₇	Z ₁₈	Z ₁₉	Z ₂₀	Z ₂₁	Z ₂₂	Z ₂₃	Z ₂₄	Z ₂₅	Z ₂₆	Z ₂₇	Z ₂₈	Z ₂₉	Z ₃₀
2016	0.1	0.01	0.01	0.01	0.1	0.01	0.1	0.08	0.01	0.01	0.1	0.01	0.01	0.01	0.1

Case3: If expected return is 40% of total investment from the investor’s choice then fund diversification of total fund done by LGP is shown in Table 6. LGP invested 100% fund with objective function value = 0.105, calculated annual return=0.295 (29.5%), beta value= 0.852 and standard deviation= 0.016 (1.6%). In this case also LGP is not able to achieve return value up to the expected level and lacking with 10.5% however risks are minimum.

Stock	Z ₁	Z ₂	Z ₃	Z ₄	Z ₅	Z ₆	Z ₇	Z ₈	Z ₉	Z ₁₀	Z ₁₁	Z ₁₂	Z ₁₃	Z ₁₄	Z ₁₅
2016	0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	0.01	0.01	0.01	0.01
Stock	Z ₁₆	Z ₁₇	Z ₁₈	Z ₁₉	Z ₂₀	Z ₂₁	Z ₂₂	Z ₂₃	Z ₂₄	Z ₂₅	Z ₂₆	Z ₂₇	Z ₂₈	Z ₂₉	Z ₃₀
2016	0.1	0.01	0.01	0.01	0.1	0.01	0.1	0.08	0.01	0.01	0.1	0.01	0.01	0.01	0.1

The performance of integrated MCDM-GP based expert portfolio system for all three cases for the data of financial year 2016-17 is shown graphically in Figure 2. This figure clearly reflects that MCDP-GP based expert system is able to achieve highest return up to 29.5% with minimum value of objective function and risks (Beta and standard deviation). Expert system is not giving return more than 29.5% however set return value is more than that.

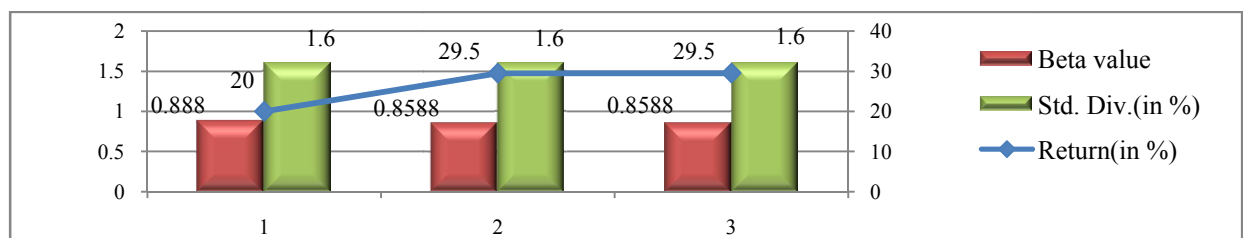


Figure2: Comparative Performance of Stock Portfolio of Year 2016-17

CONCLUSION

Investors always want to invest their fund with expected high return with minimum risk. Portfolio management is a challenging task for decision maker and can be achieved in better way using expert portfolio system. This research presents an integrated approach of MCDM and GP techniques as MCDM-GP in which MCDM is used for ranking of various indices and then GP is used to diversify the fund. Experiments were done with the data of financial year 2016-17. S & P BSE index was ranked as first among all, GP was then applied to diversify the fund with 3 different expected values of return as 20%, 30% and 40%. Results shows that GP is able to invest the entire fund with highest return of 29.5%with minimum value of risk. In the future a portfolio will be constructed using many other optimization techniques from various portfolio already exist in the market and then GP will be applied to diversify the fund.

REFERENCES

- Hota H. S., Awasthi V. K. and Singhai S. K. (2016). Comparative Analysis of AHP and Its Integrated Techniques Applied for Stock index Ranking, *Proceeding of ICACNI 2016*, 2, 127-134.
- Markowitz H. (1952). Portfolio selection, *Journal of Finance*, 91, 7-77.
- Saaty T. L. (2001). Decision Making with Dependence and Feedback: Analytic Network Process, *RWS Publications*, Pittsburgh.
- Sharma D. K., Jana R. K. and. Sharma H.P. (2013). A Hybrid Decision Support System for Equity Portfolio Management, *Journal of Money, Investment and Banking*, 28, 82-93.
- Sharma H. P. and Sharma D. K. (2005). A Multi-Objective Decision Making Approach for Mutual Fund Portfolio, *Journal of Business and Economics Research*, 3(20), 1-10.

(A complete list of references is available upon request from H. S.Hota at proffhota@gmail.com)