DESIGNING AN ANALYTIC HIERARCHY PROCESS AND GOAL PROGRAMING BASED DECISION SUPPORT SYSTEM FOR PORTFOLIO MANAGEMENT

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ABSTRACT

Portfolio management is a complex task due to conflicting nature of decision-making criteria. In literature, many researchers and practitioners have suggested decision support systems (DSS) based on multi-criteria decision-making (MCDM) techniques for managing the risk of complex investment portfolios. MCDM methods such as analytical hierarchy process (AHP) and goal programming (GP) are widespread, and may be applied to construct efficient portfolios. In this study, we have suggested a framework based on above techniques as an analytic hierarchy process (AHP) and goal programing (GP) based portfolio decision support system (PDSS) that includes tiers at the client, application, and database level for investment decisions. The PDSS is being developed using software applications including dot Net compatible language as Front End and MS-Access and flat file as Back End. The system's portfolio analytics and decision-making architecture are enriched by quantitative finance model that is formulated using AHP and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods to obtain the ranking of the portfolio and GP technique to minimize risk and maximize return on the investment.

Keywords: Portfolio Management, Goal Programming, Analytical Hierarchy Process.

INTRODUCTION

In the portfolio management, a set of good stocks is required to be chosen for the investment purpose with the objective of high return and low risk. In this regard, any ranking based selection methods like multi-criteria decision-making (MCDM) may be very useful. MCDM methods are becoming more important tools for analyzing real complex problems due to their inherent capability to analyze different alternatives on various criteria for possible selection of the best/suitable alternative (s) (Hwang and Masud, 1979; Steuer, 1986; Sharma and Sharma, 2005). The analytic hierarchy process (AHP) (Saaty et al., 1980) is a later development, and it has recently become popular. AHP is a hierarchical approach to decision-making, which involves multiple conflicting criteria to assess the relative importance of these criteria and to find the rank of the alternatives (Douligeris & Pereira, 1994: Ghosh, 2011). Also, compares alternatives for each criterion, and determines an overall ranking of the alternatives. The output of the AHP is prioritized ranking indicating the overall preference for each of the decision alternatives (Stocks in our case). The AHP modifications are considered to be more consistent than the original approach. A fuzzy version of AHP known as FAHP is more practical to incorporate the real-world problems associated with portfolio management.

Literatures proves that MCDM methods are widely used in engineering, science, agricultural and financial domains (Ehrgott et al., 2004; Lee et al., 2009; Sharma et al., 2014). Nepal et al. (2010) presented an FAHP framework to determine the prioritization weights of customer satisfaction attributes to facilitate the target planning decision to improve vehicle design. Sen (2010) and Dagdeviren (2009) have also used AHP and TOPSIS methods along with its fuzzy version for solving selection related problems. Many authors have combined and introduced other advanced version of MCDM methods and utilized in various areas (Awasthi & Chauhan, 2012). These includes Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Simple Additive Weighting (SAW) and its integrated approaches and fuzzy version of MCDM methods. Also, goal programming (GP) and its variants have been applied to portfolio management problems (Lee, 1972; Pendaraki et al., 2004; Sharma & Sharma, 2005).

This paper proposed a framework to combine AHP and TOPSIS with GP and its fuzzy versions for portfolio management to design a structure and to develop a portfolio decision support system (PDSS) to assist the financial managers, investors, and others for the intelligent decision-making process. PDSS will provide a graphical user interface (GUI) to choose the type of MCDM methods to find the rank of the stocks to construct a portfolio and then GP will be utilized to diversify the fund in the dynamically constructed portfolio.

MCDM METHODS

MCDM problems have two categories: multi-attribute decision making (MADM) and multi-objective decision making (MODM) (Hwang and Masud, 1979; Steuer, 1986; Sharma and Sharma, 2005). AHP and TOPSIS methods fall into the class of MADM. These methods apply to consider qualitative criteria such as market conditions and investor preferences. On the other hand, the goal programming (GP) technique categorizes into the class of MODM and useful for quantitative criteria and serves as an optimizer for building a portfolio that fits the investor's goals. GP is one of the most widely used techniques for solving MODM problems (Romero, 1991).

AHP and TOPSIS methods select best alternatives with conflicting nature of criteria with complex mathematical calculation after constructing pair-wise comparison. Problem may be decomposed in the form of hierarchy as shown in Figure 1, where root of the hierarchy consists of objective while middle of the hierarchy consists criteria (C1, C2, C3, etc.) and leaf consists alternatives (A1, A2, A3, A4 etc.). In AHP (Sharma et al., 2014) pair-wise comparison matrix using Saaty's 9 points scale is first constructed followed by calculating geometric mean, Eigen value, consistency ratio (CR) and finally consistency index (CI). In the next step, we compare the alternatives pair-wise with respect to how much better they are in satisfying each of the attributes, i.e., to ascertain how well each alternative serves each attribute and final weights are obtained. On the other hand, TOPSIS calculates weights of the alternatives by calculating positive ideal solutions (PIS) and negative ideal solutions (NIS) and then by obtaining distance of each alternative (Separation measures) from PIS and NIS. A combination of AHP and TOPSIS is also used to form a new AHP-TOPSIS method, where weights of AHP are utilized further to find out rank of the alternatives using TOPSIS. Fuzzy MCDM methods are the fuzzy version of MCDM methods where membership values are assigned for constructing pair-wise comparison matrix instead of crisp values. Finally, GP is proposed and combined with AHP and TOPSIS to diversify the available fund among the selected stock/Index.

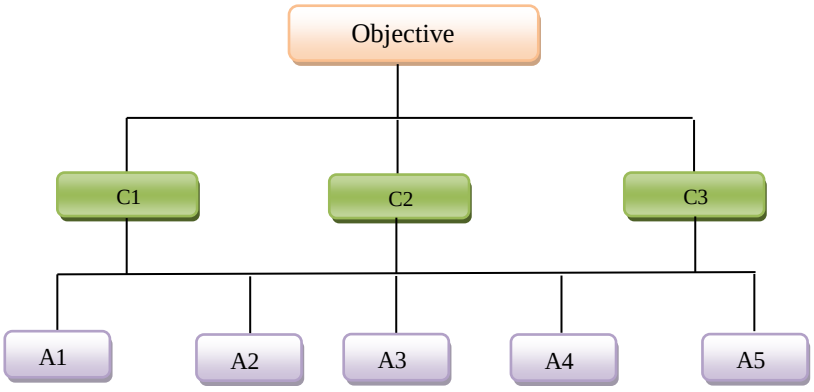

Figure 1: The Decision Hierarchy

PROTOTYPE OF PDSS BASED ON MCDM METHODS AND GP

The prototype of PDSS in combination of MCDM methods and GP is shown in Figure 2. Stock data with various criteria like beta, dividend, P/E ratio, return, etc. with stock as alternatives may be obtained from various financial sites like yahoo finance and Bombay stock exchange. A hierarchy using these criteria and alternatives may be constructed as shown in Figure 1 as step 1. Step 2 of Figure 2 is the core part which describes about PDSS using various MCDM methods as explained above. The components of PDSS can be viewed as three different layers - Layer 1: GUI, Layer 2: MCDM methods, and Layer 3: Programming Environment. Each layer of PDSS is explained in detail as below:

Layer 1: Graphical User Interface (GUI)
The proposed software will provide interactive GUI to select MCDM methods such as AHP, FAHP and FTOPSIS and to load financial data to construct portfolio with various alternatives and criterion with option of n number of alternatives and criterion and finally the rank of the alternatives will be displayed on the screen. User can also import intermediate data calculation of all the MCDM methods to flat files for further verification. The facility of exporting data from MS-Access database and flat files will also be available. GUI will also support the user to crate and verify portfolio in dynamic manner and the best portfolio with high return and low risk may be stored permanently in database.

Layer 2: MCDM Methods
The software will comprise many MCDM methods like AHP, TOPSIS and its fuzzy version FAHP and FTOPSIS. PDSS users may choose any method or all the methods to find out the rank of the Stock or Index for constructing a portfolio. PDSS will also provide a comparative rank of all the MCDM methods to choose the best alternatives.

Layer 3: Programming Environment
Proposed PDSS is a combination of front end as '.Net' compatible language and back end as 'MS-Access' and flat files.

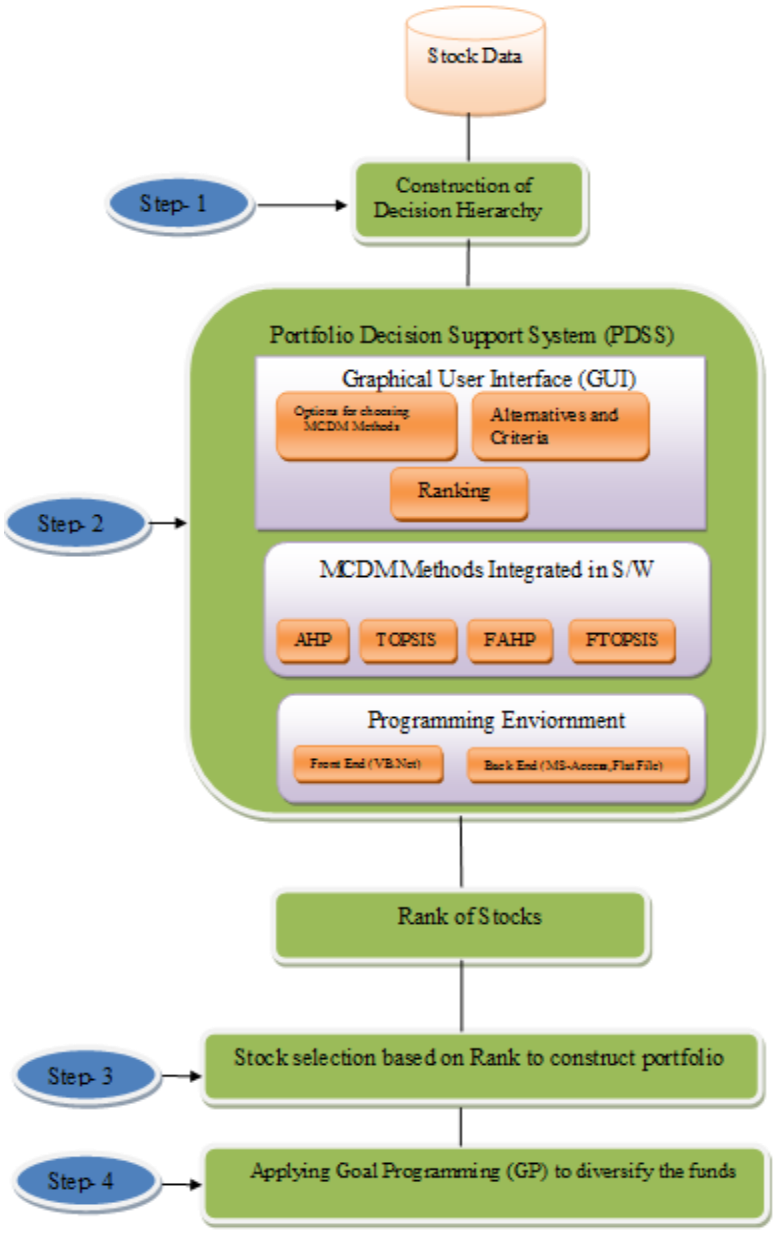

Figure 2: Prototype of PDSS in combination of MCDM methods and GP

Rank of the stock/Index is obtained from step 3 and finally in step 4 GP is proposed to be combined to diversify the available fund among the selected stock/Index. The number of stock/Index may be chosen based on the rank obtained through many ranking based MCDM methods through PDSS. PDSS also provides information to construct a portfolio in a dynamic manner from the ranked stock/Index to verify the returns.

CONCLUSION

A decision support system is widely used in the financial domain specially for constructing portfolio. The proposed work provides a two-layered architecture for constructing portfolio using proposed PDSS, which will first find out rank of the stock/Index and then will provide facility to diversify the fund among the ranked stock/Index in dynamic manner. The GUI of PDSS will provide interactive way to select alternatives and criteria in dynamic manner and also to import data from the flat files and data base.

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