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Investment Portfolio Management Using Computational Intelligence

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Abstract: Portfolio is a part of an investment and risk-limiting strategy called diversification. The assets in the portfolio could include bank accounts, stocks, bonds, options, gold certificates, real estate. Portfolio management involves deciding what assets to include in the portfolio, given the goals of the portfolio owner and changing economic conditions.
To achieve the objective Modern portfolio theory (MPT) is applied to investment portfolio. Modern portfolio theory (MPT) is a theory of investment which tries to maximize portfolio expected return for a given amount of portfolio risk, or equivalently minimize risk for a given level of expected return, by carefully choosing the proportions of various assets. MPT is a mathematical formulation of the concept of diversification in investing, with the aim of selecting a collection of investment assets that has collectively lower risk than any individual asset.

Keywords: Optimal Portfolio, Diversification, Asset Correlation, Risk Management, Historical Analysis

I. INTRODUCTION

Modern portfolio theory (MPT) is a theory of investment which attempts to maximize portfolio expected return for a given amount of portfolio risk, or equivalently minimize risk for a given level of expected return, by carefully choosing the proportions of various assets.

MPT is a mathematical formulation of the concept of diversification in investing, with the aim of selecting a collection of investment assets that has collectively lower risk than any individual asset. That this is possible can be seen intuitively because different types of assets often change in value in opposite ways. For example, as prices in the stock market tend to move independently from prices in the bond market, a collection of both types of assets can therefore have lower overall risk than either individually. But diversification lowers risk even if assets' returns are not negatively correlated—indeed, even if they are positively correlated.

The fundamental concept behind MPT is that the assets in an investment portfolio should not be selected individually, each on their own merits. Rather, it is important to consider how each asset changes in price relative to how every other asset in the portfolio changes in price.

Investing is a tradeoff between risk and expected return. In general, assets with higher expected returns are riskier. For a given amount of risk, MPT describes how to select a portfolio with the highest possible expected return. Or, for a given expected return, MPT explains how to select a portfolio with the lowest possible risk.

II. RELATED WORK

A. Fundamental Analysis

Fundamental analysis of a business involves analyzing its financial statements and health, its management and competitive advantages, and its competitors and markets. When applied to futures and forex, it focuses on the overall state of the economy, interest rates, production, earnings, and management. When analyzing a stock, futures contract, or currency using fundamental analysis. Fundamental analysis is performed on historical and present data, but with the goal of making financial forecasts.

B. Market Based Valuation

Market-based valuation is a form of stock valuation that refers to market indicators, also called "extrinsic" criteria. Technical analysis is the most characteristic market-based method, although it focuses more on timing than pricing.

C. Capital Asset Pricing Model

In finance, the capital asset pricing model (CAPM) is used to determine a theoretically appropriate required rate of return of an asset, if that asset is to be added to an already well-diversified portfolio, given that asset's non-diversifiable risk. The model takes into account the asset's sensitivity to non-diversifiable risk, often represented by the quantity beta (β) in the financial industry, as well as the expected return of the market and the expected return of a theoretical risk-free asset.

MPT is based on the Capital Asset Pricing Model & it has an edge over the above mentioned various methodologies. Advantages of MPT are as follows:

- Diversification strategy is used.
- Correlation between the assets is considered.
- Optimization is performed.

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III. MODERN PORTFOLIO THEORY

A. Risk And Expected Return

MPT assumes that investors are risk adverse, meaning that given two portfolios that offer the same expected return, investors will prefer the less risky one. Thus, an investor will take on increased risk only if compensated by higher expected returns. Conversely, an investor who wants higher expected returns must accept more risk. The exact trade-off will be the same for all investors, but different investors will evaluate the trade-off differently based on individual risk aversion characteristics.

Under the model:

Portfolio return is the proportion-weighted combination of the constituent assets' returns.

Portfolio volatility is a function of the correlations ρ_{ij} of the component assets, for all asset pairs (i, j).

In general:

Expected return:

$$E(R_p) = \sum_i w_i E(R_i)$$

Where R_p is the return on the portfolio, R_i is the return on asset i and w_i is the weighting of component asset i (that is, the share of asset i in the portfolio).

Portfolio return variance:

$$\sigma_p^2 = \sum_i w_i^2 \sigma_i^2 + \sum_i \sum_{j!=i} w_i w_j \sigma_i \sigma_j \rho_{ij}$$

Where ρ_{ij} is the correlation coefficient between the returns on assets i and j.

Alternatively the expression can be written as:

$$\sigma_p^2 = \sum_i \sum_j w_i w_j \sigma_i \sigma_j \rho_{ij}$$

Where $\rho_{ij} = 1$ for i=j.

Portfolio return volatility (standard deviation):

$$\sigma_p = \sqrt{(\sigma_p^2)}$$

For a two asset portfolio:

Portfolio return:

$$E(R_p) = w_A E(R_A) + w_B E(R_B) = w_A E(R_A) + (1 - w_A) E(R_B)$$

Portfolio variance:

$$\sigma_p^2 = w_A^2 \sigma_A^2 + w_B^2 \sigma_B^2 + 2 w_A w_B \sigma_A \sigma_B \rho_{AB}$$

For a three asset portfolio:

Portfolio return:

$$w_A E(R_A) + w_B E(R_B) + w_C E(R_C)$$

Portfolio variance:

$$\sigma_p^2 = w_A^2 \sigma_A^2 + w_B^2 \sigma_B^2 + w_C^2 \sigma_C^2 + 2 w_A w_B \sigma_A \sigma_B \rho_{AB} + 2 w_A w_C \sigma_A \sigma_C \rho_{AC} + 2 w_B w_C \sigma_B \sigma_C \rho_{BC}$$

B. Diversification

An investor can reduce portfolio risk simply by holding combinations of instruments which are not perfectly positively correlated (correlation coefficient $-1 <= \rho_{ij} < 1$)). In other words, investors can reduce their exposure to individual asset risk by holding a diversified portfolio of assets. Diversification may allow for the same portfolio expected return with reduced risk.

If all the asset pairs have correlations of 0—they are perfectly uncorrelated—the portfolio's return variance is the sum over all assets of the square of the fraction held in the asset times the asset's return variance (and the portfolio standard deviation is the square root of this sum).

The efficient frontier with no risk-free asset Efficient Frontier.

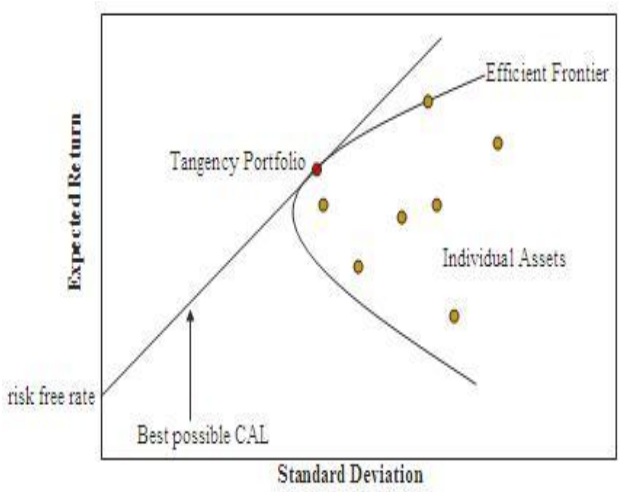

Figure 1. Efficient Frontier

The hyperbola is sometimes referred to as the 'Markowitz Bullet', and is the efficient frontier if no risk-free asset is available. With a risk-free asset, the straight line is the efficient frontier.

As shown in this graph, every possible combination of the risky assets, without including any holdings of the risk-free asset, can be plotted in risk-expected return space, and the collection of all such possible portfolios defines a region in this space. The left boundary of this region is a hyperbola, and the upper edge of this region is the efficient frontier in the absence of a risk-free asset (sometimes called "the Markowitz bullet"). Combinations along this upper edge represent portfolios (including no holdings of the risk-free asset) for which there is lowest risk for a given level of expected return. Equivalently, a portfolio laying on the efficient frontier represents the combination offering the best possible expected return for given risk level.

IV. DESIGN AND IMPLEMENTATION

A. Process Flow

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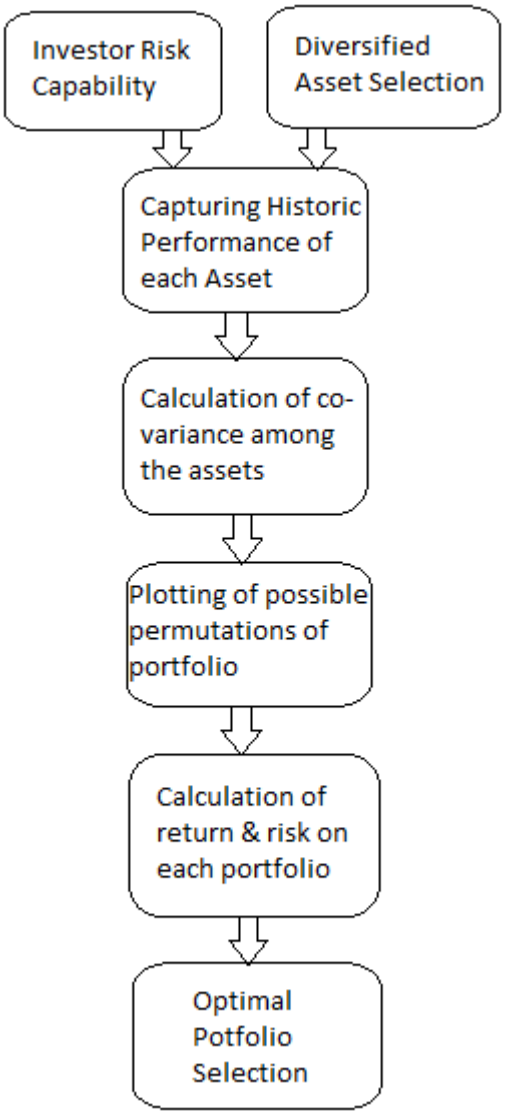

Figure 2. Process Flow

B. Architecture Diagram

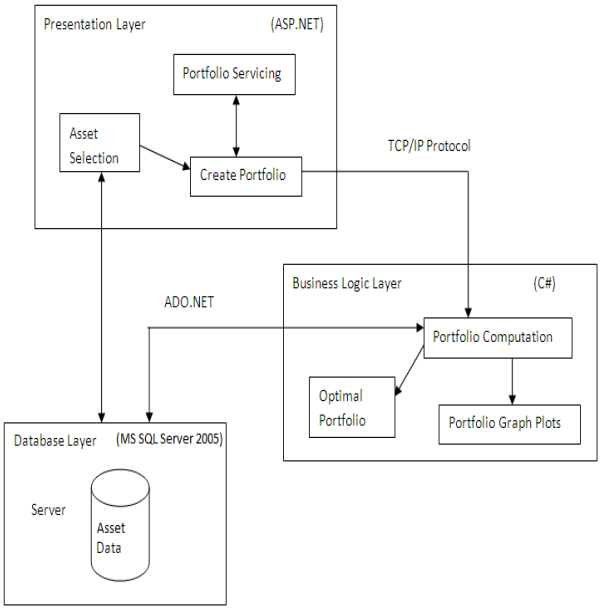

Figure 3. Architecture Diagram

C. System Description

Modern Portfolio Management and Portfolio Servicing System is 2-tier web client-server architecture.

The first layer is at client side which opens in browser. It is used for following purposes:

- To collect user personal and financial data of user
- To validate user
- To provide Asset selection facility (Customer's facility)
- To show results for portfolio returns (Customer's facility)
- To show Current track of different Assets 'DASHBOARD' is used (Customer's facility)
- To show history of different Assets 'PERFORMANCE' is used (Customer's facility)
- To create Portfolio 'CREATE PORTFOLIO' is used (Customer's facility)
- To modify Portfolio 'PORTFOLIO SERVICING' is used (Customer's facility)

Second layer is at the web server side and performs business logic. It also interacts with system database. Modern Portfolio Theory model is implemented at this side. Store procedure which Interacts with data base is implemented. Historic data for the assets is fetch using web client at this layer from the yahoo server. As MPT is web client – server architecture client's response is catch at

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client side and processing of response is done at server. Client is connected to Web application server by Internet. To fetch historic Data of assets web application server is connect to yahoo server by internet.

D. System Operation

System Operations can be classified in following categories:

1. Risky and non-risky asset selection:

User selects assets to make up his portfolio. On selecting assets he has to confirm by clicking on confirm button to view optimize complete portfolio.

2. Fetch historic data for selected assets:

Web client request is made to yahoo server. Separate web request is made for each asset. Historic data of assets is stored in data table.

Following web client uses the download string function:

```
wc.DownloadString(@"http://ichart.finance.yahoo.com/table.csv?s=" + symbol + "&a=" + _startmonth + "&b=" + _startdate + "&c=" + _startyear + "&d=" + _endmonth + "&e=" + _enddate + "&f=" + _endyear + "&g=w&ignore=.csv");
```

3. Calculation of asset return and variance:

Following operation are performed iteratively for each asset.

Return = ((present day closing value – last day closing value) / closing value)*100

$$\text{Variance} = \sum_{i=1}^{n} (xi - x') / n$$

Where n = number of data elements of x

x = per day return

x' = mean return

4. Computation of correlation matrix and covariance matrix

Correlation = $(n(\sum xy)-(\sum x)(\sum y)) / \sqrt{([n(\sum x^2) - (\sum x)^2][n(\sum y^2)-(\sum y)^2])}$

Where n = number of data elements of x & y

x = per day return of asset say 'a'

y = per day return of asset say 'b'

5. Execution of Solver:

Correlation matrix, minimum expected return are passed to solver. Solver gives all possible solutions. Assets weights, expected return, standard deviation and minimum returns for various possible solution is computed.

6. Optimal Portfolio:

Risk-free rate of non-risky assets and Solver results is used for calculating optimal portfolio. X Y Line graph is plotted .Expected return is plotted on X axis and standard deviation is plotted on Y axis. A line is drawn with Y intercept as risk free rate of return. The line is drawn such that it makes maximum slope with risk return curve. That tangent point gives the optimal risky portfolio.

7. The Proportion of risk free & risk assets is calculated.

Proportion of risky assets = (return on risky assets – return on risk free assets) / Risk aversion index of user * Covariance of risky assets)

Proportion of risk free assets = 1 - Proportion of risky assets

V. CONCLUSION

Portfolio management is the professional management of various securities (shares, bonds and other securities) and assets (e.g., real estate) in order to meet specified investment goals for the benefit of the investors.

Investors may be institutions (insurance companies, pension funds, corporations etc.) or private investors (both directly via investment contracts and more commonly via collective investment schemes e.g. mutual funds or exchange-traded funds).

The system will play an instrumental role in managing the funds.

Mathematical theory combined with software tools will yield maximum profit.

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