An Intelligent Decision Support System Prototype for Asset Allocation

Hamid Nemati
The University of North Carolina

Lakshmi Iyer
University of Dayton

Follow this and additional works at: http://aisel.aisnet.org/amcis1999

Recommended Citation
http://aisel.aisnet.org/amcis1999/24

This material is brought to you by the Americas Conference on Information Systems (AMCIS) at AIS Electronic Library (AISeL). It has been accepted for inclusion in AMCIS 1999 Proceedings by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.
An Intelligent Decision Support System Prototype for Asset Allocation

Hamid R. Nemati, The University of North Carolina, nemati@uncg.edu
Lakshmi S. Iyer, University of Dayton, iyer@udayton.edu

Abstract

Asset allocation decision involves bringing together estimates of current capital conditions and investor considerations in order to determine the asset allocation mix that will provide maximum utility to the investor. This can be accomplished by either maximizing return for a given risk level or by minimizing the risk for a given return objective. The purpose of this study is to develop a prototype decision support system that will provide a model for an investor to use in determining the optimal asset allocation for an investment portfolio at a particular risk level. This DSS consisted of five primary components. In this paper, we limited our discussion to the neural network (NN) component. The results of NN model can then be used as input to a quadratic programming model to determine the optimal asset allocation.

Introduction

Asset allocation decision is the most critical decision influencing the return of an investment portfolio (Bitters 1997; Arnott and Fabozzi 1992; Aby and Vaughn 1995). The optimal allocation mix can be determined in two ways: by maximizing return for a given risk level or, alternatively, minimizing the risk for a given return objective. In this study we develop a prototype decision support system that provides support for an investment decision-maker in determining the optimal asset allocation for an investment portfolio at a particular risk level. We limit our model prototype to three asset classes (stocks, bonds, and t-bills) although the method can be easily applied to any number of asset classes. This prototype decision support system uses a Neural Network (NN) model to determine capital market expectations for portfolio allocation decisions. The result of this model are then used to solve a quadratic programming problem in order to determine the optimal asset allocation. To do this, we use our capital market variables (output), obtained from the neural network model as constants in the quadratic programming model. The quadratic programming model allows the decision maker to specify user constraints (in our case, the maximum amount that can be allocated to a particular asset class); the changing variables (in our case, the weights for each asset class in the portfolio); and the objective function (in our case, maximizing the risk adjusted return of the portfolio while holding the portfolio standard deviation and the investor risk tolerance level constant). However, in the current paper, we limit our discussion to the development and implementation of the neural network model.

The Asset Allocation Decision

The asset allocation decision is a complex and unstructured decision problem and is intended to support the investment advisory process. The overall objective of this decision problem always remains maximizing the attainment of the investor’s goals. The investment advisory process is summarized in Figure 1. The major components of this process include the decision to be made (determining the optimal asset allocation mix); the stochastic variables (current capital market conditions); and a number of consequences (predicted capital market conditions, investor constraints, the investor utility function, an investor’s net worth, and the return of the optimal asset allocation mix). The asset allocation decision involves bringing together estimates of current capital market conditions (predictions of return, correlations, and standard deviations for each asset class) and investor considerations (investor constraints and utility functions) in order to determine the asset allocation mix that will provide maximum utility for the investor.

Background

Artificial Neural Networks (ANN) are systems that mimic the physical structure of the brain in order to store knowledge and to achieve learning. ANN are composed of many simple processing elements (nodes or neurons) operating in parallel. Signals are passed between the nodes over interconnecting links each with an associated weight. A given neuron receives signals from other neurons as input and applies an activation function to the input set to determine the output signal. Knowledge is acquired through a learning process which modifies the strengths of the interconnecting weights. A neural network is trained rather than programmed. The challenge in using NN as a decision support system tool is justifying a particular policy or process change based on the output of a tool that does not provide an explanation capability and whose intricacies are relatively unknown to the end users.

However, a review of literature pertaining to the application of NNs in investment decision making
indicates that NNs can provide better modeling results than typical regression-based models (Smith 1990; Barr and Bhagat 1994; and Levin 1995). NN possess a superior ability to deal with non-linear and “noisy” data which is characteristic of financial data. NN is very useful in that no a priori assumptions regarding relationships between variables need to be made. In financial markets, little is known about the relationships between variables. Bunn et al. (1995) present a comprehensive example of using NN to estimate the returns on the stock, bond, and cash asset classes. The authors also outline how NN can be used in the asset allocation process. The authors compared their predictions with those of a comparable multiple linear regression model and concluded that the NN performed better, both in- and out-of-sample, than the comparable linear regression model.

NN models are also known to outperform other methods when data quality is suspect. The Bansal, Kaufman and Weitz study (1993) demonstrates that, for purposes of determining forecasting Mortgage Backed Securities (MBS) prepayments, a NN model was better at using erroneous data than a comparable regression model. The performance of a forecasting model is directly related to the quality of the data used to derive the model. The problem for decision-makers is that good-quality data is expensive, so managers must often try to develop good models to handle poor-quality data.

**Modeling the Asset Allocation Decision**

The methodology used for this prototype decision support system utilizes a NN model to determine the capital market inputs for use in the optimization process. This methodology is an extension of the work proposed in Bunn et al. (1995). Our Asset Allocation decision support system has five principle elements (see Figure 2). The data analysis and preprocessing and database elements are necessary elements of the final asset allocation model, but not explicit components of this prototype. In our model, data analysis and preprocessing were performed external to the above system. In practice, this component would contain statistical tools, graphical analysis, and possibly an expert system to aid in determining relevant variables to include in the data set and appropriate data transformations. Similarly, in the final allocation model, historical data on macro-economics indicators, market indexes, and portfolio information would be stored explicitly in a separate relational database. The preprocessing component of the asset allocation model transforms variables into appropriate types (percentage change, ordinal, etc.) and configures the data set for the NN model component. In the prototype, the database component is incorporated principally within the preprocessing component. There, historical data on macro-economic indicators and market indexes may be referenced.

**Figure 2. Asset Allocation Decision Support System Architecture.**

In our model, to implement the NN component, BackPack© software package was used to predict the
return, correlation, and standard deviations for three asset classes: domestic stocks, corporate bonds, and t-bills. These predicted values are then used in determining the optimal asset allocation mix. Since we are concerned with asset allocation, as opposed to specific security selection, indices for the stocks (the NYSE composite index) and bonds (an index of 10-year corporate bonds) were chosen. Stocks, bonds, and t-bills are the broadest and most basic asset classes. Our modeling methodology could be used for other asset classes (foreign stocks, small cap stocks, etc.) in determining capital market expectations for these asset classes.

**Data Considerations and NN Design**

We predict the return on the NYSE index (stocks), 10-year corporate bonds (bonds), and t-bills based on variables drawn largely from the leading Business Cycle Indicators (BCI). We used 240 months’ worth of data (Jan/75-Dec/95) to predict the following variables:

- Expected Annual Return on NYSE composite index (%)
- Expected Annual Return on 90-day T-bills (%)
- Expected Annual Return on Investment Grade, 10-year Corporate Bonds (%)

The preprocessed data was loaded into the NN for model design and training. The initial design phase was similar for each asset class. We used BackPack’s default percentage settings for the initial training, testing and validation data sets.

**NN Results and Evaluation of Asset Allocation Model**

After each network was trained, the validation sets were run through the model for each asset class. All three models appeared to satisfy the criteria when tested for assumptions of the regression mode: linearity, constant variance, independence of the residuals, and normality. The resulting neural networks for the various asset classes yielded the following results:

<table>
<thead>
<tr>
<th></th>
<th>T-bills</th>
<th>Corporate Bonds</th>
<th>Stocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation Coefficient</td>
<td>0.8766</td>
<td>0.8260</td>
<td>0.9138</td>
</tr>
<tr>
<td>RMSE</td>
<td>0.0611</td>
<td>0.0821</td>
<td>0.0301</td>
</tr>
<tr>
<td>MAPE</td>
<td>17.47</td>
<td>10.94</td>
<td>111.0</td>
</tr>
</tbody>
</table>

Looking at the high correlation coefficients and low root mean squared error (RMSE), our models appear to be relatively accurate in predicting the returns of our three asset classes. Using the prediction points obtained from NN, the standard deviations for each asset class and the covariances among the asset classes were calculated. The results of the hypothetical current investment date of July 1995 are summarized as follows:

<table>
<thead>
<tr>
<th></th>
<th>T-bills</th>
<th>Corporate Bonds</th>
<th>Stocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Return</td>
<td>7.53%</td>
<td>10.37%</td>
<td>13.27%</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>2.56%</td>
<td>1.71%</td>
<td>33.05%</td>
</tr>
<tr>
<td>Covariances</td>
<td>0.003755</td>
<td>0.000221</td>
<td>0.002687</td>
</tr>
</tbody>
</table>

These results are then used in the optimization model in order to determine, in conjunction with the standard deviation of the portfolio, the optimal asset mix that will create the maximum return. In addition to the statistical measures, we also use system objectives such as profitability, consistency, and robustness to evaluate the model. The primary goal of the Asset Allocation Model is to produce financial value. The amount of value produced by our system, as with any financial allocation or trading system, will be determined by its performance over time.

**Conclusions**

In this paper, we proposed a prototype intelligent decision support system to assist in asset allocation decision. This DSS consisted of five primary components. The scope of this paper is limited to the discussion of the NN component. This NN model is used to determine capital market expectations for portfolio allocation decisions. We predicted the return on the NYSE index (stocks), 10-year corporate bonds (bonds), and t-bills based on variables drawn largely from the leading Business Cycle Indicators (BCI). We used 240 months’ worth of data (Jan/75-Dec/95) for training, testing, and validating the NN model. The results of NN model can then be used as input to a quadratic programming model to determine the optimal asset allocation.

**References**

Available upon request from Nemati, H.R.