SST 95-96

SUMMER STIPENDS
1995-1996 Academic Year
Application Cover Sheet

PATSY RECORD # _____

Project title: Can a Neural Network Forecast Monthly Treasury Bill Rates?

Applicant's Name: Malliaris [Last] Mary [First] E [Initial]

Social Security Number: 442-48-8271

Department: Management Science

==========

Category *Please check all descriptions that apply, so as to ensure that your application is given full consideration in all competitions for which it may be eligible.*

1. Are you a member of the:
   - [X] School of Business
   - [ ] School of Law
   - [ ] School of Nursing

2. Does your project fall within the humanities? _____

3. At the University level, do you believe your application should be reviewed with other projects in
   - [ ] humanities and fine arts
   - [ ] physical and natural sciences
   - [X] social sciences

   [IF SELECTING MORE THAN ONE, PLEASE INDICATE FIRST AND SECOND CHOICE CLEARLY]

==========

Abstract Please limit your abstract to the space provided below. Do not photoreduce your material.

It is the purpose of this study to investigate the predictability of short term interest rates using the methodology of multi-layer perceptron neural networks with back propagation. Federal Reserve Board policies in setting these short-term rates has a phenomenal impact, not only on stock markets, but on every individual since their influence is directly reflected in mortgage rates, credit loans for automobiles and charge card rates. Manufacturing companies across the country make decisions about worker cutbacks and production schedules based on how they expect the Federal Reserve to set short-term interest rates. If a neural network can capture the strategic management style of the current Federal Reserve Chairman and its Board and thus forecast Treasury Bill rates, a rational response to these changes could be formulated both by individuals and by corporations.

CAN A NEURAL NETWORK FORECAST MONTHLY TREASURY BILL RATES?

1. Introduction and Significance

During 1994, The Dow Jones Industrials Average moved sideways, fluctuating between 3600 and 4000, and closed on December 30, 1994 at 3834. In contrast, since the beginning of 1995, the Dow Jones Industrials Average has increased by 25% to its current value of 4784. This move translates to an increase in wealth for all equity holders of about 1.5 trillion dollars. Most analysts agree that interest rates, both the short-term 3 month Treasury Bill rate and the long-run 30 year Treasury Bond rate, have been the catalysts for this move.

Among numerous financial variables, short term interest rates play a very significant role in influencing the evolution of the economy, partially because they reflect the various strategies of the Federal Reserve Board. For example, given one set of data about the rate of unemployment, the consumer price index, industrial production, and new housing starts, analysts would offer different interpretations of this data, depending on whether short term rates were going up or down. Suppose that the rate of unemployment is slowly decreasing, the consumer price index is stable, and industrial production and new housing starts are slowly increasing. If, to such a scenario, we add that Treasury Bill rates are slowly declining, then one would conclude that we are in the early phases of a cycle with the Federal Reserve attempting an easy monetary policy to sustain economic growth. On the other hand, if interest rates are rising, one would reach the opposite conclusion, namely, that the economy is at an advanced cyclical phase with the Federal Reserve attempting to keep the lid on inflation.

The key relationship that lends support to the significance of short term interest rates is the policy decisions of the Federal Open Market Committee (FOMC). When this Committee meets about 10 times a year, it studies numerous indicators exhaustively and decides by member voting to set Fed Funds targets. The FOMC, consisting of six members of the Federal Reserve Board and five presidents of various Federal Reserve banks under the chairmanship of the Chairman of the Federal Reserve Board, sometimes errs in its assessment of the economy's condition. However, the resources in terms of data, analysis and evaluation that the FOMC has at its disposal, makes market participants pay enormous attention to the FOMC's assessment and Fed Funds policy decisions. This attention is justified both because of the superior information that the FOMC possesses as well as because Fed Funds targeting immediately influences short term Treasury Bill rates.

This brings us to the topic of this proposal: are Treasury Bill rates predictable on the basis of other earlier acquired information? There are two broad categories of answers given to the question of Treasury Bill rate predictability. One claims that such rates cannot be predicted while the other provides some evidence of partial predictability. Needless to say, no one has ever claimed complete predictability.

Among the numerous studies that offer support to the non-predictability of short term interest rates, most are variants of the efficient market hypothesis and its random walk statistical description of interest rates. Some recent studies include Shiller, Campbell and Schoenholtz(1983), Cook and Hahn (1989), Simon (1990), Campbell and Shiller (1991), Rudebusch (1992) and Blough (1994).

On the other hand, several researchers have been able to demonstrate the existence of some degree of predictability, for example Hardouvelis (1988), Mishkin (1988) , and Mankiw and Miron (1986, 1991).

Researchers have used a variety of statistical methods to investigate this problem. Typical methods include time series analysis as in Rudebusch (1992), econometric estimation as in Fama (1984) or Froot (1989), or instrumental variables as in Simon (1989). The traditional approach in studying this problem is to establish relationships and test them empirically using statistical techniques. These methods have difficulty in capturing the extensive nonlinearities in the data and better tools are needed to analyze Fed policies.

It is the purpose of this study to investigate the predictability of short term interest rates using the methodology of multi-layer perceptron neural networks with back propagation. These networks use an abundance of input data to infer an underlying structure. This structure does not have to be specified apriori. Rather, the network itself, through repeatedly looking at the data and readjusting the importance of the data connections, attempts to discover the relationships. The backpropagation neural network has been applied to other financial problems such as managing investment funds (Fishman, et. al. (1991)), pricing gold futures (Grudnitski and Osburn (1993)), estimating options prices (Malliaris and Salchenberger (1993)), and forecasting the S&P volatility (Malliaris and Salchenberger (1995)), and has had good success in dealing with nonlinear data.

Fed policies have a phenomenal impact, not only on stock markets, but on every individual since their influence is directly reflected in mortgage rates, credit loans for automobiles and charge card rates. Manufacturing companies across the country make decisions about worker cutbacks and production schedules based on how they expect the Federal Reserve to set short-term interest

rates. If a neural network can capture the strategic management style of the current Federal Reserve Chairman and its Board and thus forecast Treasury Bill rates, a rational response to these changes could be formulated both by individuals and by corporations.

2. Research Plan

This project consists of three basic components: (a) bibliographic research and data collection; (b) determination of the neural network architecture and parameters, and (c) using the resulting architecture to train the network and develop forecasts.

The bibliographic search and data collection have been completed. Monthly data for the period from January 1980 to the present have been collected on Treasury Bills and related variables. Each series of data has about 180 observations.

The next step is to determine the best architecture and parameters for a given neural network. This involves a series of tests with the data in which various neural network combinations are built, tested, and progressively refined until a satisfactory model has been constructed. Three neural networks models will be constructed and their effectiveness in forecasting compared. The first network will use Treasury Bill rates and lags an input variables. The second network will use these inputs along with inflation and industrial production data. The last network will use monthly Treasury Bill rates along with excess inflation and excess growth as input variables. In all cases, the output variable will be next month's Treasury Bill rate. This should take three to four weeks.

Finally, the neural networks will be trained on 18 months of data and used to make weekly forecasts for the following 3 month time period. The window of training data will then be moved forward 3 months and the training and forecasting process will be repeated. This process will continue until the entire set of data has been forecasted. The results will be evaluated by calculating the mean squared error, mean absolute deviation and mean absolute percent error for each of the forecasting periods. To train, forecast and analyze the network results should take about four weeks. The results will then be prepared for publication and an article is expected by December, 1996.

Bibliography

Blough, S.R., 1994, "Yield Curve Forecasts of Inflation: A Cautionary Tale", *New England Economic Review*, Federal Reserve Bank of Boston, 3-15.

Campbell, J.Y. and R.J. Shiller, 1991, "Yield Spreads and Interest Rate Movements: A Bird's Eye View", *Review of Economic Studies*, 58, 495-514.

Cook, T. and T. Hahn, 1989. "The Effect of Changes in the Federal Funds Rate Target on Market Interest Rates in the 1970s", *Journal of Monetary Economics*, 24, 331-351.

Fama, E.F., 1984, "The Information in the Term Structure", *Journal of Financial Economics*, 13, 509-528.

Fishman, M., D. Barr, and W. Loic, 1991, "Using Neural Nets in market Analysis", *Technical Analysis of Stocks and Commodities*, 9, 18-22.

Froot, K.A., 1989, "New Hope for the Expectations Hypothesis of the Term Structure of Interest Rates", *Journal of Finance*, 44, 283-305.

Grudnitski, G. and L. Osburn, 1993, "Forecasting S&P and Gold Futures Prices: An Application of Neural Networks", *Journal of Futures Markets*, 13, 631-643.

Hardouvelis, G.A., 1988, "The Predictive Power of the Term Structure During Recent Monetary Regimes", *The Journal of Finance*, 43, 339-356.

Malliaris, M. and L. Salchenberger, 1993, "A Neural Network Model for Estimating Option Prices", *Journal of Applied Intelligence*, 3, 193-206.

Malliaris, M. and L. Salchenberger, 1995, "Using Neural Networks to Forecast the S&P 100 Implied Volatility", *Neurocomputing*, 9, forthcoming.

Mankiw, N.G. and J.A. Miron, 1986, "The Changing Behavior of the Term Structure of Interest Rates", *Quarterly Journal of Economics*, 101, 211-228.

Mankiw, N.G. and J.A. Miron, 1991, "Should the Fed Smooth Interest Rates? The Case of Seasonal Monetary Policy", *Carnegie-Rochester Series on Public Policy*, 34, 41-70.

Mishkin, F., 1988, "The Information in the Term Structure: Some Further Results", *Journal of Applied Econometrics*, 3, 307-314.

Rudebusch, G., 1992, "Trends and Random Walks in Macroeconomic Time Series: A Re-examination", *International Economic Review*, 33, 661-680.

Shiller, R.J., J.Y. Campbell, and K.L. Schoenholtz, 1983, "Forward Rates and Future Policy: Interpreting the Term Structure of Interest Rates", *Brookings Papers on Economic Activity*, 1, 173-224.

Simon, D.P., 1989, "Expectations and Risk in the Treasury Bill Market: An Instrumental Variables Approach", *Journal of Financial and Quantitative Analysis*, 24, 357-365.

Simon, D.P., 1990, "Expectations and the Treasury Bill -- Federal Funds Rate Spread Over Recent Monetary Policy Regimes", *Journal of Finance*, 45, 467-477.