Another Way To Pair Trade

Neural Network Pair Trading

Pair trading is a market-neutral trading strategy. But how do you find the right pair? Using neural networks, of course.

by Marge Sherald

Are you taking a second look at market-neutral trading systems in today's difficult markets? Pair trading is popular, but finding the right pair is more challenging. Neural networks offer an alternative to traditional pair-matching methods.

The usual pair-trading strategies speculate on future convergence of a price spread between similar securities. Once a pair is identified, the customary rule is to buy one security and sell the other short in an attempt to create a market-neutral trading system. The trades are initiated when the two normalized securities prices diverge a specified amount, often by two standard deviations. The trades are exited when the prices once again converge.

Instead of crossing normalized prices, neural nets use one stock to predict another. Trading signals are generated based on the spread between the actual and predicted values. The optimized neural net can even select the security used to make the prediction from a basket of securities; the neural net can be a matchmaker of sorts.

Once the neural net has found the pair, another artificial intelligence technique — a genetic algorithm optimizer — can customize buy/sell decisions for a particular pair rather than using static rules such as buy when the pair diverges by two standard deviations. In Figure 1, you see three energy stocks that could be candidates for a pair-trading system.

BUILDING ALTERNATIVE PAIR MODELS

We're going to build our pair-trading system in two steps:

1. Build a neural network prediction for the price of one stock based on another stock in the same sector.
2. Use the spread between the actual and predicted values of the stock to generate simultaneous buy/sell hedging signals for the stock used as the basis for the prediction and the predicted stock.

NEURAL NETWORK PREDICTION

We decided to model several stocks in the utility sector, which are described in a paper by trader/analyst Binh Do as homogenous due to their stable demand and product similarity.

We constructed a chart with prices for Consolidated Edison (ED), Pepco Holdings (POM), and Southern Company (SO). Using NeuroShell Trader Professional, we created a neural network prediction for the Consolidated Edison close using the Pepco

FIGURE 1: PAIR TRADING CANDIDATES. Three energy stocks that follow one another but don't cross prices may still be candidates for a pair trading system using a neural network to pick the pair.

close and the Southern Co. close as possible inputs (or independent variables) to the model. We set up the optimizer to find a neural network with a maximum of one input, forcing the optimizer to decide whether the closing price of Pepco or Southern Co. produces a more accurate model for the closing price of Consolidated Edison.

For proper hedging, we need to force the creation of a "trivial" neural network that makes a linear prediction than a nonlinear one. We want to limit the accuracy of the network because we want a "loose fit" rather than a highly accurate prediction. In our system, we accomplish this by setting the number of hidden neurons to zero.

After training the neural net, the prediction analysis window in the NeuroShell Trader Professional displays a percentage contribution of each of the inputs to the model. Since we directed that the net only uses one input, the net chose Pepco with a 100% contribution factor as the best stock to use for predicting the price of Consolidated Edison. The contribution factors are displayed in Figure 2.

The actual and predicted values are graphed on the chart in Figure 3. Note that the actual and predicted values cross one another often and then spread apart. The relationship of whether the actual close is above or below the predicted value will determine which stock is bought and which stock is sold short in the trading rules. The magnitude of the spread will determine the timing.

We also verified that the predicted value of Consolidated

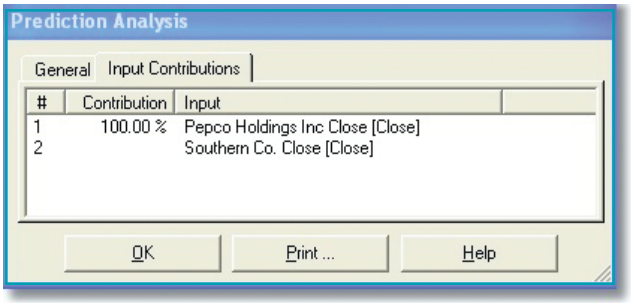

FIGURE 2: NEURAL NET PICKS. The neural network chose Pepco with a 100% contribution factor as the best input for the model that predicts Consolidated Edison. The genetic algorithm was configured to select a neural network with only one input, so Southern Co. was eliminated from the model.

Edison moves in the same direction as Pepco. This directional correlation is essential for a normal hedging situation.

TRADING RULES

Traders using traditional pair models often use complicated spread metrics between two securities to gauge entry and exit points — that is, the sum of the squared differences between normalized prices. The neural network method, however, compares simple differences between the actual and predicted prices. The prices are in the same range so they don't need to be normalized. For simplicity, we use the absolute value of the difference between the actual and predicted values as the spread in the trading rules.

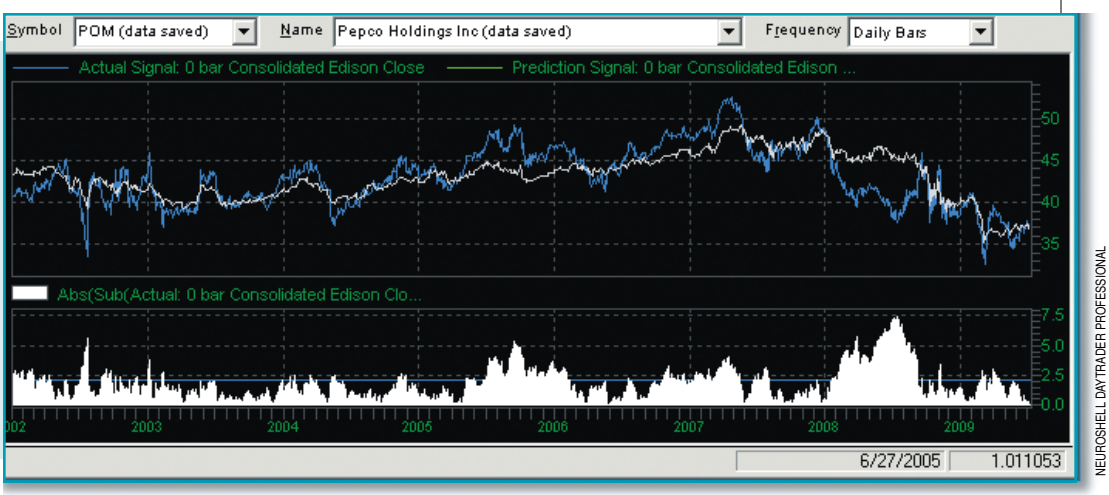

FIGURE 3: ACTUAL AND PREDICTED VALUES. The "loose fit" predicted values from the neural network (white line) are graphed against the actual close (blue line) for Consolidated Edison. The spread between the predicted and actual values will be used to develop simultaneous trading signals for Consolidated Edison and Pepco. The lower graph displays the absolute value of the differences between the actual and predicted values of ED.

IMPLEMENTING THE PROXY PAIR TRADING SYSTEM IN NEUROSHELL TRADER PROFESSIONAL

Create a daily chart for Consolidated Edison. Using the Insert Menu, select Other Instrument data and then choose Pepco and Southern Co., as well as another copy of the close for Consolidated Edison.

Insert a prediction with the following settings:
Inputs: Other instrument data versions of Pepco and Southern Co.
Output: Close of Consolidated Edison
Lookforward: Zero trading days into the future
Input Optimization: Input selection
Data used to evaluate prediction: Optimization (match chart)
Positions: No trading positions
Training Objective: Minimize mean squared error
Advanced training parameters: Zero hidden neurons
Optimization: Maximum numbers of inputs = 1

After training the neural net, click on the Prediction Analysis button, examine the input contribution factors, and note which of the input stocks received a 100% contribution factor (in this case, Pepco). Add a chart page for that stock to the existing chart.

Insert the actual and predicted values on the chart in the same subgraph.

Insert an indicator that calculates the absolute value of the spread between the actual and predicted values for use in the trading rules.

Insert a trading strategy:
We used the ProxyEntry and ProxyExit indicators from Advanced Indicator Set 3 to create the trading rules. These are unique indicators that cause the trader to go long on one stock and simultaneously short on another stock within the same chart. There are other techniques that do not require the use of these indicators and they are described on our technical support website.

Long and short entry rules:
Insert the Relational Indicator A = B.
A = ProxyEntry indicator (see below for details)
B = 1 for the Long Entry and -1 for the Short Entry.
The B values are used to keep track of the simultaneous trades on both stocks and should not be optimized.

All entries use the same ProxyEntry parameters in order for the trades to occur simultaneously.

ProxyEntry parameters:
Close = Close of the current chart page
price 1 = Consolidated Edison close
price 2 = Pepco Holdings close
proxy1 = Actual value of the Consolidated Edison close
proxy2 = Predicted value of the Consolidated Edison close
spread = 3 (set according to the spread between actual and predicted values)

Long and short exit rules:
All exits use the same ProxyExit parameters in order for the trades to occur simultaneously.

ProxyExit parameters:
Close = Close of the current chart page
proxy1 = Actual value of the Consolidated Edison close
proxy2 = Predicted value of the Consolidated Edison close
spread = 1 (the exit spread)
stopspread = 5

The entry spread value for the long entry and short entry is linked (optimized to the same value) so that the trades occur simultaneously and the system maintains market neutrality. The exit spread and stop spread values are linked and optimized in a similar manner.

IMPLEMENTING THE TRADING RULES

We begin by adding a chart page for Pepco to the chart we previously made for the neural net prediction of Consolidated Edison. Next, we construct trading rules based on the following considerations:

1. For entry positions, is the actual close of Consolidated Edison greater or less than the predicted value, and did the spread between the actual and predicted values widen to meet or exceed an entry threshold?
2. For exit positions, did the spread narrow enough in order to equal or fall below an exit threshold?
3. For a protective stop, did the spread widen enough in order to equal or exceed a stop threshold?

The genetic algorithm optimizer in the NeuroShell Trader Professional found the optimal spread values used in the rules. Other optimization techniques may be used, including manual trial and error backtesting. However, the genetic algorithm optimizer speeds up the process significantly because it uses the evolutionary techniques to search for values that are more effective in solving the problem rather than trying every possible solution.

Note that in the rules the spread values for entries, exits, and protective stops are the same for both stocks in order for the trades to occur simultaneously and keep the trading system market neutral.

Entry rules for Consolidated Edison (ED)
Long entry rules:
Actual value of ED < predicted value of ED
And the absolute value of the spread between actual and predicted values of ED crosses from below the threshold of 2.69 to equal or above the threshold.

Short entry rules:
Predicted value of ED < actual value of ED
And the absolute value of the spread between actual and predicted values of ED crosses from below the threshold of 2.69 to equal or above the threshold.

Entry rules for Pepco (POM)
Long entry rules:
Predicted value of ED < actual value of ED
And the absolute value of the spread between actual and predicted values of ED crosses from below the threshold of 2.69 to equal or above the threshold.

Short entry rules:
Actual value of ED < predicted value of ED
And the absolute value of the spread between actual and predicted values of ED crosses from below the threshold of 2.69 to equal or above the threshold.

Exit rules for both ED and POM
Long and short exit rules:
The absolute value of the spread between the actual and predicted values of ED <= 0.23

BUY & HOLD VERSUS NEURAL NET PAIR TRADES RESULTS SUMMARY

	Backest Period		Out-of-Sample Period	
	Jan 2, 2002 - Dec 31, 2008		Jan 2, 2009 to Sept 16, 2009	
Individual Stock Trades	Percent Return/Loss	Dollars	Percent Return/Loss	Dollars
Consolidated Edison Buy and Hold	-4.90%	($494.44)	4.70%	$470.30
Consolidated Edison Trading Strategy	27.40%	$2,733.07	8.70%	$866.43
Pepco Holdings Inc. Buy and Hold	-21.80%	($2,182.00)	-17.20%	($1,717.60)
Pepco Trading Strategy	52.90%	$5,287.77	22.30%	$2,230.89
Combined Pair Trades	Backtest Period	Out-of-Sample Period		
Buy and Hold	($2,676.44)	($1,247.30)		
Trading Strategy	$8,020.84	$3,097.32		

FIGURE 4: RESULTS SUMMARY. The results summary shows that the neural net trading strategy beat a buy & hold strategy during both the backtest period and during the out-of-sample period.

Or hit a protective stop when the absolute value of the spread between the actual and predicted values of ED >= 4.6.

All exit rules are the same in order for the trades to occur simultaneously. See sidebar, "Implementing The Proxy Pair Trading System In NeuroShell Trader Professional."

Optimizing the Trading Rules

Some judgment should be exercised in setting up the optimization to find the optimal spreads. Reasonable ranges in which the optimizer will search should be used. The values for the spread ranges should be based on the specific pair being traded. In any case, make sure that the optimizer obeys the following relationship: exit spread < entry spread < stop spread.

We set the spread ranges for Pepco/Ed pair as follows:

Entry spread:	2 to 4
Exit spread:	0.01 to 1.9 (when the actual and predicted values are coming together)
Stop exit:	4.1 to 6 (values that occur rarely)

Summary

The results displayed in Figure 4 show that the pair trading strategy is profitable in the out-of-sample (trading) period for both the predicted stock, Consolidated Edison, and the stock used to make the prediction, Pepco. The model was back-tested over the 2002–08 period and remained profitable in the out-of-sample period from January 2 to September 16, 2009, a particularly challenging time in the markets. Profits are based on investing $10,000 in each stock on all trade entries. Commissions are $2 for each trade.

These results demonstrate that you can use a neural network to create a successful pair trading system with stocks in different price ranges. The close of one stock is used to predict another. The spread for the pair trade is calculated as the difference between the net's actual and predicted values. These spread levels may be optimized to determine profitable entry and exit points.

Marge Sherald is chief operating officer of Ward Systems Group and has authored a number of articles on financial forecasting, expert systems and neural networks. She participates in the design of Ward Systems Group products, is responsible for documentation and training videos, and teaches NeuroShell Trader seminars.

Suggested Reading

Chan, Ernest P. [2009]. *Quantitative Trading*, John Wiley & Sons.

Do, Binh, and Robert Faff [2009]. "Does Simple Pairs Trading Still Work?" Monash University.

Do, Binh, Robert Faff, and Kais Hamza [2006]. "A New Approach To Modeling And Estimation For Pairs Trading," Monash University.

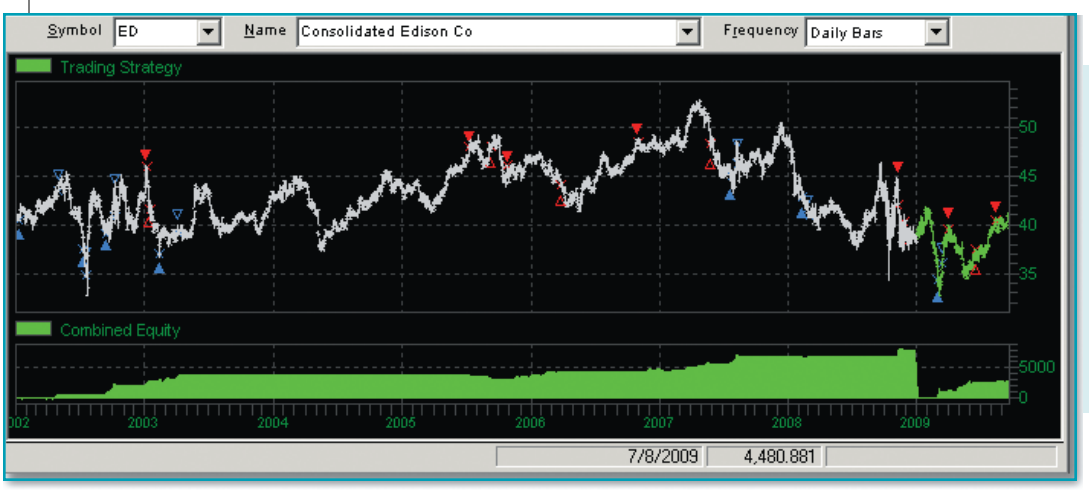

FIGURE 5: TRADING SIGNALS. The chart displays the trading signals for the neural net pairs trading strategy. The white line corresponds to the in-sample data used to create the model. The green line corresponds to the out-of-sample period in 2009. Note that the equity curve calculation in the bottom subgraph restarts in 2009, corresponding to the out-of-sample data.