Naive System

Before expending a lot of energy designing and testing mean reversion systems, we will examine a naive system to see whether SPY, and other highly liquid ETFs and equities exhibit mean reversion or trend following behavior.

As readers of my companion book, Modeling Trading System Performance, will recognize, I recommend systems that trade frequently, hold for a short period of time, and have a high percentage of winning trades. The systems described in this chapter are not finished systems. They are intended to be exploratory and should not be traded without extensive testing and validation by the trader.

**Buy After an N-Day Sequence**

Defining a day as either a rising day or a falling day based on whether the most recent close is higher or lower than the previous day’s close, we can test the feasibility of buying after a sequence of rising days or a sequence of falling days.

Every trading system involves making some subjective decisions. For this system, they include:

- **Issue traded** — SPY
- **Date range** — 1/1/1999 to 1/1/2012
- **Indicator** — A sequence of rising or falling daily prices.
- **Action** — At the close of the signal bar.
- **Commission and slippage** — none.
- **Positions** — Long only.
- **Objective function** — CAR / MDD.
Every system has some parameters. For this system they include:
- **N** — The number of consecutive closes in the same direction.
- **Direction** — Rising (1) or falling (0).
- **HoldDays** — Maximum holding period in days.
- **ProfitTarget** — Exit intra-day when this percent profit can be realized.

The rules are:
- **Buy** — N consecutive closes in the same direction.
- **Sell** — At the close of the maximum holding period, or at the profit target, whichever is reached first.

Listing 3.1 shows the AmiBroker code.

```plaintext
// BuyAfterAnNDaySequence.afl

SetOption( "ExtraColumnsLocation", 1 );
SetOption ( "CommissionMode", 2 ); // $ per trade
SetOption( "CommissionAmount", 0 );
SetOption( "InitialEquity", 100000 );
SetPositionSize( 10000, spsValue );
MaxPos = 1;
SetOption( "MaxOpenPositions", MaxPos );
SetTradeDelays( 0, 0, 0, 0 );
BuyPrice = Close;
SellPrice = Close;

// Define a day as rising based on the closing price
Rising = C > Ref( C, -1 );
Falling = C < Ref( C, -1 );

// The number of days in the sequence
N = Optimize( "N", 3, 1, 7, 1 );

// Direction. 1 == Rising, 0 == Falling
Direction = Optimize( "Direction", 1, 0, 1, 1 );

// Exit variables
// Maximum holding period
HoldDays = Optimize( "HoldDays", 4, 1, 7, 1 );
// Profit target
ProfitTarget = Optimize( "ProfitTarget", 0.4, 0.2, 4, 0.2 );

// Detect an N day sequence
if ( Direction == 1 )
{
    NDaySequence = Sum( Rising, N ) == N;
}
```
Listing 3.1 -- Buy After an N-Day Sequence

The optimization statements call for testing of:
- **N** days from 1 to 7.
- Direction both Rising and Falling.
- Holding Period from 1 day to 7. In AmiBroker, both the entry day and the exit day are counted. Since entry is made at the close of one day and the earliest exit is at a profit target the following day, the shortest period reported will be for a 2 day holding period.
- ProfitTarget from 0.2% to 4.0%.

Figure 3.1 shows the result of the optimization, sorted by CAR / MDD (Compound Annual Return / Maximum Drawdown).

The parameters are in the first four columns in the same order they occur in the program. Namely, N, Direction, HoldDays, ProfitTarget.

Note that the best result has parameter values of 3, 0, 7, 0.4. Buy at the close of a day that completes a sequence of 3 falling days, take a profit of 0.4% as soon as possible, exit at the close of the 7th day (6th day after entry). And the second best, which has a better K-ratio, exits on day 4.
Figure 3.2 shows the equity curves and drawdown curves for the best system (with the seven day hold).

Figure 3.2 -- Equity curve and drawdown curve
Figure 3.3 shows the statistics for the best system.

**Figure 3.3 -- Statistics**

**Discussion**

The code includes a variable that represents direction. If a long position is taken as the price is rising, that is trend following. If a long position is taken as the price is falling, that is mean reverting. So the program represents two different trading systems and gives us the opportunity to
test and compare trend following (when Direction is 1) and mean reversion (when Direction is 0) in the same run.

The default optimizer is exhaustive, so all possible combinations were tested. (AmiBroker also supports non-exhaustive optimizations / searches, and these will be used in later examples to reduce execution time.)

980 combinations of parameter values were tested for rising prices, and 980 for falling.

All of the best alternatives shown in Figure 3.1 have a Direction of 0, meaning take a long position after a sequence of falling prices — a mean reversion system.

Buying when prices have been rising is trend following. 164 of the trend following alternatives showed a net profit, 816 showed a net loss. The best trend following system had parameters of 1, 1, 7, 0.6. It entered a long position after a single rising day, took profit at 0.6%, and exited on day 7.
Figure 3.4 shows the equity chart and drawdown chart for the best trend following system. Compare with Figure 3.2, which shows the same information for the best mean reversion system.

Buying when prices have been falling is mean reverting. 912 of the mean reverting alternatives showed a net profit, 68 were not profitable.

**Validation**

Having 93% of the alternatives tested profitable shows that the system is fairly robust. But these results come from testing all available data. No data was reserved for out-of-sample testing, which is generally a poor practice and over estimates profit and under estimates risk. In later studies better validation techniques, including walk forward testing, will be used.
These tests suggest that SPY has been mean reverting over the recent past. Expanding the date range to include the entire history of SPY (in a study not shown here), it has been mean reverting since it was originally published in 1993 and continues to be in summer 2012.

We can test the system using other tradable issues. There is no guarantee that every system will work for every issue, nor is there a requirement that it must. But it is interesting and valuable to know which issues tend to be mean reverting and which tend to be trend following.

Two watchlists have been prepared and will be used for cross-tradable testing throughout this book.

One is a list of 14 highly liquid ETFs:

- SPY
- QQQ
- IWM
- EEM
- GLD
- XLB
- XLE
- XLF
- XLI
- XLK
- XLP
- XLU
- XLV
- XLY

The other is a list of 32 issues that meet two criteria:
- They are highly liquid. They are among the 100 most liquid issues as of 2012.
- Their price as of 1/1/2012 is within a few percent of their price 1/1/1999. Their net buy and hold performance for 13 years is roughly flat — there is no bias to being long or short over that period.

They are a mixture of ETFs and common stocks. Their ticker symbols are:

- AEP
- DELL
- IVV
- SMH
- ALL
- DIS
- KO
- SPY
- BAC
- EWJ
- MRK
- T
- BA
- F
- MS
- TWX
- CMCSA
- GE
- MSFT
- VZ
- COF
- HD
- PFE
- WY
- CSCO
- HNZ
- QQQ
- XLU
- DD
- INTC
- RTN
- XLV

The 3, 0, 7, 0.4 values found when studying SPY were used to test these two groups. Figure 3.5 shows the results of trading each issue alone, sorted by CAR/MDD. 36 of the 42 issues were profitable. None of the 6 unprofitable issues had serious losses, and even those 6 had winning trade percentages in the high 80 percent range.
Returning to analysis of SPY, it is interesting to compare the naive mean reversion system to some ideal trend following systems.

The zigzag indicator uses a single numerical argument — the minimum percentage change between peaks and valleys. Applied to closing prices, a zigzag of a certain percentage, say 5%, forms a series of trends where every upward or downward segment is at least 5% and has no retracements greater than 5%. If a system had perfect knowledge of future prices, it could identify the zigzag bottoms as they were being formed. Assume such a system took a long position on the close of the first day following a bottom, then sold using the same holding period and profit target rules as the naive mean reversion system. The percentage was adjusted until the number of trades and percentage exposure of the

Figure 3.5 -- Naive mean reversion results

Comparison with ideal trend following

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ideal zigzag system roughly matched that of the naive mean reversion systems. A zigzag percentage of 1.80% was selected. Figure 3.6 shows the equity curve and drawdown curve for the result.

Figure 3.6 -- Equity curve for perfect trend following system
Figure 3.7 shows the summary statistics.

![Statistics Table]

**Extension of mean reversion system**

Continuing analysis of the mean reversion system based on a sequence of days with falling prices, Figure 3.8 shows a chart of SPY for a six month period in 2011 with upward arrows below the bars that complete a sequence of three falling days. The system described takes a single
position at the first occurrence of three falling days. There are times when a long position has not been closed, but additional falling days would cause additional signals. See Figure 3.8 and the multiple arrows in the circled bars.

Figure 3.8 -- Signals for entries using 3 falling days

The program was modified so that entries required a sequence of 4, 5, and 6 falling days, and a backtest was performed for each. Figures 3.10, 3.11, and 3.12 show the trades for those systems, respectively, for the period covered in Figure 3.8.

Figure 3.9 shows the trade results, based on the sequence of three falling days, for the period in Figure 3.8.

Figure 3.9 -- Trade list for signals using 3 falling days in Figure 3.8

The program was modified so that entries required a sequence of 4, 5, and 6 falling days, and a backtest was performed for each. Figures 3.10, 3.11, and 3.12 show the trades for those systems, respectively, for the period covered in Figure 3.8.

Figure 3.10 -- Trade list for 4 falling days

Figure 3.11 -- Trade list for 5 falling days
These are seven additional trades that were not signaled by the original code. All seven were profitable.

Note that the trade entered on June 3 using the original 3 day sequence resulted in a loss of 0.84%. If longer sequences are recognized and multiple positions allowed, several additional trades would have been signaled. The four trades entered on June 6 and 8 from a 4 day sequence, June 7 using a 5 day sequence, and June 8 using a 6 day sequence resulted in a total gain of 1.71%, recovering from the 0.84% loss.

Figure 3.13 shows three equity and drawdown curves. They represent using 4, 5, and 6 day sequences of falling closing prices to enter a long trade, respectively.

In my opinion, these should be treated as separate systems, not as “scaling-in.” Each of the systems should be evaluated on its own merit.
The original code was modified to allow multiple positions and to enter on any sequence of three or more falling days. Figure 3.14 shows the resulting equity and drawdown curves.

![Figure 3.14 -- Equity curve allowing multiple positions](image)

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Figure 3.15 shows the associated statistics.

Listing 3.2 shows the AmiBroker code.

// BuyAfterNDaySequenceMultiPosition.afl

//
SetOption( "ExtraColumnsLocation", 1 );
SetOption( "CommissionMode", 2 ); // $ per trade
SetOption( "CommissionAmount", 0 );
SetOption( "InitialEquity", 100000 );
SetPositionSize( 10000, spsValue );
MaxPos = 7;
SetOption( "MaxOpenPositions", MaxPos );
SetBacktestMode( backtestRegularRawMulti );
SetTradeDelays( 0, 0, 0, 0 );
BuyPrice = Close;
SellPrice = Close;
// ObFn == K-ratio, CAR/MDD, expectancy

// Define a day as rising based on the closing price
Rising = C > Ref( C, -1 );
Falling = C < Ref( C, -1 );

// The number of days in the sequence
N = Optimize( "N", 3, 1, 7, 1 );

// Direction. 1 == Rising, 0 == Falling
Direction = 0; // Optimize( "Direction", 0, 0, 1, 1 );

// Exit variables
// Maximum holding period
HoldDays = Optimize( "HoldDays", 4, 1, 7, 1 );
// Profit target
ProfitTarget = Optimize( "ProfitTarget", 0.4, 0.2, 4, 0.2 );

// Detect an N day sequence
if ( Direction == 1 )
{
    NDaySequence = Sum( Rising, N ) >= N;
}
else
{
    NDaySequence = Sum( Falling, N ) >= N;
}

Buy = NDaySequence;
Sell = 0;

ApplyStop( stopTypeProfit, stopModePercent, ProfitTarget );
ApplyStop( stopTypeNBar, stopModeBars, HoldDays );

// Plots
Plot( C, "C", colorBlack, styleCandle );
shapes = IIf( Buy, shapeUpArrow, shapeNone );
shapecolors = IIf( Buy, colorGreen, colorWhite );
PlotShapes( shapes, shapecolors );

Listing 3.2 -- N-Day Multiposition System
Extreme oversold

Look in particular at the large loss by the final trade in the 6 day sequence in Figure 3.13. While there are only 12 trades in the 13 year period signaled by a sequence of 6 falling days, too few to draw conclusions, it is often the case that the most extreme oversold conditions are poor entries. One colleague gave the analogy of taking a cold remedy -- one teaspoon helps, two teaspoons helps a lot, three teaspoons makes him worse.

Summary

We have discovered a simplistic, naive mean reversion system that could be traded. Its results are realistic and achievable. It is applicable to a wide range of tradable issues. Its results are roughly comparable to a nearly ideal trend following system that requires perfect knowledge of the future, giving us confidence that mean reversion systems are practical alternatives to trend following systems.

The remainder of this book expands development of mean reversion systems.