Chapter 3

Trading Systems

Modeling Trading System Performance is a sequel to my earlier book, *Quantitative Trading Systems (QTS).* Those readers who are familiar with *QTS* may comfortably skip this chapter.

In *Quantitative Trading Systems*, I outline the process of design, testing, and validation of trading systems that I think is necessary in order to have reasonable confidence that a trading system can be profitable in the future.

As I set out to write *QTS*, I wanted to avoid having my book placed on the shelf in that section reserved for books that espoused nebulous and untestable ideas, often written with the intent of selling some additional product or service. I wanted every reader to be able to think about my statements and ideas, incorporate their own thoughts and alternatives, and test them using a professional-grade trading system development platform.

I chose AmiBroker to implement the concepts in *QTS.* Not because I have a partnership relationship with AmiBroker. I do not. I purchased my copy of AmiBroker at full retail price. I chose AmiBroker because it was the only platform I could find that was capable of implementing the procedures I feel are essential to successful trading systems. As an added benefit, the cost of AmiBroker is about one-tenth the cost of other popular platforms, even though none of those are capable of the necessary tasks.

Even though *QTS* uses AmiBroker, it is much broader in scope than being just an AmiBroker book.

If you have not yet read *QTS*, I encourage you to do so. The brief outline in this chapter cannot do justice to its 368 pages of text, including some 80 fully explained and coded examples.

The next few pages outline the key points about trading systems I feel are not only important, but essential. In the final analysis, the question each and every designer of a trading system must ask before he or she makes their first trade is "How confident am I that this system will work tomorrow with real money?"

Quantitative

I am a strong believer in the quantitative approach to trading. For me to consider making a trade based on some concept, I must be able to write a set of rules that describe that concept, test those rules over the

historical data of the tradable issue, and become reasonably confident that the system will work on unseen data. I have no argument with people who can successfully interpret chart patterns. To the extent those patterns can be described and quantified, they are candidates for quantitative trading.

Objective Function

I am a strong believer that the personal and professional preferences and requirements of the trader and his or her organization should form the basis for the trading systems used. In particular, I believe that the design of the system should match the person or organization right from the start. I know how difficult it is for me to change my thoughts or behavior to accept some concept or perform some act contrary to my personality.

By proper design and implementation of the objective function (or fitness function) by which trading results can be measured and compared, those trading systems that rank high are very likely to be tradable without cognitive dissonance. I recommend designing the system to match the person, rather than trying to train the person to accept a system that does not match his personality or requirements.

System Design

The premises of technical analysis are:

- The market is sufficiently inefficient that there are patterns in the data that can be recognized that precede profitable trading opportunities.
- Those patterns are persistent enough that trading systems can be designed, tested, and validated, with enough time remaining for profitable trading.

As I define and describe it, a trading system has two components:

- The logic and set of rules that defines the model.
- The data the model processes.

The data consists of two components:

- Signal that contains the profitable patterns.
- Noise, which is everything not specifically recognized as signal, even if it contains valuable information that could be detected by some other set of logic.

Entries are important. There are many valid techniques for entering trades:

- Trend following, such as breakout or moving average cross-over.
- Mean regression, including buying weakness and selling strength.
- Comparative relative strength, such as rotation among sectors.
- Patterns, such as sequences of prices.
- Seasonalities, such as times of the month or phases of the moon.
- Statistics, based on analysis of price action following some condition.
- Cycles.

Exits are important. There are several ways to exit a trade:

- Sell signal determined by the rules.
- Holding period maximum.
- Profit target.
- Trailing exit, such as parabolic.
- Maximum loss stop.

The logic defines the rules. The data defines the price series. Together they comprise a trading system.

It is not necessary to trade the series used to develop the model. In my simple-minded one-liner: "Model something easy, trade something profitable." For example, it is often easier to develop a trading system using an index-related exchange traded fund (ETF) than using an individual security. But it can be much more profitable to make the trades in the individual security, or in a related ETF.

In-sample Testing

The period of time, and the data associated with that time, used to refine the rules is called the in-sample period and the in-sample data.

The length of the in-sample period is "whatever length best fits the system." Using too long a period includes data that represents many periods of time and many different economic conditions. It is difficult to fit a single model to many conditions. Using too short a period re-

duces the opportunity for the model to identify and synchronize itself with the signal component of the data.

System development is a repeated cycle of test and modify, until the results are acceptable.

The process of optimization is testing many alternatives of logic and parameter values, searching for those that are best. Best is measured by the objective function. Optimization in itself is neither good nor bad. It is simply an organized method for performing the search.

The results of in-sample testing are always good. We do not stop fooling with the system until the results are good.

Out-of-sample Testing

Due to the repeated adjustment of the logic to fit the in-sample data, there is a serious risk that the model has become over-fit to the data; that it has learned to recognize the noise component rather than the signal component.

Out-of-sample testing is used to check for over-fitting and to give an estimate of future performance of the system. Out-of-sample is testing done using data that was not used during development of the system.

Financial data is different than other data used for experiments and statistical tests. Every time a trading system makes a profitable trade, it removes some of the inefficiency that it was designed to recognize. If enough systems recognize and profitably trade based on that same inefficiency, they will remove the inefficiency, and the characteristics of data in the future will be different. Consequently, out-of-sample data must be more recent than in-sample data.

The length of the out-of-sample period is "as long as the system continues to perform profitably."

Eventually every system fails. Without periodic adjustment to changing conditions, either the model falls out of synchronization with the data or the inefficiency has been removed. In either case, the system is no longer profitable. Perhaps the parameters can be adjusted by returning to the in-sample phase. Or perhaps the system will never work again.

Walk Forward Validation

Practice is important. Whether we are performing an athletic activity or trading, we want to be comfortable with the action and confident that it will go smoothly. One of the critical actions for a trading system designer is the transition from development to live trading. There is no doubt that tomorrow is out-of-sample.

Walk forward testing is the process of repeating a series of steps:

1. Select an in-sample period of time.
2. Perform an organized search for the set of parameters that perform best using the in-sample data. That is, re-optimize.
3. Rank the results using the objective function.
4. Select the single set of parameters associated with the best result.
5. Move the time period forward and select an out-of-sample time period that immediately follows the in-sample period.
6. Test the profitability of the system on the out-of-sample data, and record those results.

Continue to step forward, moving both the in-sample period and out-of-sample period by the length of the out-of-sample period, until the final out-of-sample period includes the most recent data. Record the values for the parameters for the most recent step.

Evaluate the concatenated out-of-sample results from all the walk forward steps. Look at the trade statistics, such as the percentage of winning trades, expected gain per trade, win to loss ratio, maximum system drawdown, and so forth. Also plot and examine the equity curve. Decide whether these results are good enough to risk trading tomorrow. If you do decide to trade the system, use the latest values of the parameters—those chosen during the final walk forward step.

Walk forward testing provides two essential functions:

1. Every walk forward step is a practice step in the transition between in-sample testing and out-of-sample trading.
2. The concatenated out-of-sample results are the best estimate of the future performance of the trading system.

Monitor Real-time Results

If the performance as measured by the walk forward tests is not adequate, do not trade the system. Return to the design, test, and validation stages.

If it is adequate, the degree of confidence the designer of the system can have about the future performance is directly related to the degree of objectivity that was used during its development and the results of the walk forward tests.

Even when that confidence is very high at the time the system is put into operation, the system will go through periods of both good and poor performance.

It is essential to monitor the real-time results, and to have a basis with which to compare them.

Summary

Modeling Trading System Performance assumes that the reader has worked through the system development process and has a trading system that has been trading or appears to be tradable.

When everything is going well, confidence is high, the model is in sync with the data, and profits are good. The important question is "What position size should be used for the next trade in order to maximize equity growth while minimizing risk of ruin?"

Eventually, performance fades. As it would be inappropriate to take a position of any size if the system is broken, the important question then is "Is the system working or is it broken?"

This book is intended to give the reader the techniques and tools to answer both those questions.