CHAPTER 1

On Trading Strategies

T rading strategies have been around for as long as people have traded organized markets. Whereas some might quarrel with me in this usage I will state unequivocally that by the terms *automated trading strategy* and its short form *automated strategy*, I mean all of the following terms: *trading systems*, *mechanical trading systems*, *trading model*, and *algorithmic trading*.

In the final analysis, I believe that any successful trader, discretionary or automated, does trade with a systematic trading strategy. In the end, as I think you will see if you work through this book, it is difficult to generate long-term and above-average trading or investment returns without a systematic approach.

Interest in technical methods and trading strategies tends to wax and wane with interest in the markets themselves. Interest in the markets tends to wax and wane with the dynamism of the markets and with the attendant opportunity, or lack thereof, for trading profits.

In the 10 years before the first edition of this book, *The Design, Testing, and Optimization of Trading Systems* (DTOTS) published by John Wiley & Sons in 1991, interest in trading systems enjoyed tremendous growth. This was due to two main developments.

The first development was the growth in the markets themselves. Not only did a major bull market develop in equities, but the 1980s led to the introduction and development of a number of new futures markets too numerous to mention. The bulk of this new growth was in financial futures, which have completely eclipsed the commodities markets of the 1970s and the 1980s. More money chased more markets. And the money

was smarter too, much of which came from institutional, *professional* traders.

The second development was the explosive growth of inexpensive computing power, which, in turn, brought about growth in the power and availability of sophisticated trading as well as trading strategy development and testing software.

The collaboration of these two primary developments and others produced the beginnings of a renaissance in technical trading methods and trading strategies. One might consider the early 1990s as the birth of algorithmic trading, that is, mechanical and without human judgment.

Since then, as I detailed in the Preface, these trends have accelerated at a pace that makes the early 1990s seem sleepy in comparison. Computing power has reached levels that would have been considered nearly impossible in 1990. The proliferation of markets and trading volume has been almost as explosive. Global trading volume has grown over 1,470 percent. In 1990, global volume of all futures contracts traded was 802,158,782. At the end of 2006, that figure stood at 11,859,266,610. The increase in non-U.S. trading volume has grown over 2,890 percent (7,286,007,180 in 2006 versus 251,771,924 in 1990). The increase in U.S. trading volume was a mere 831 percent (4,573,259,430 in 2006 versus 550,386,858 in 1990). This clearly shows the increasing globalization of futures trading.

This produced, circa 1990, a type of parity with the individual investor and the professional trader, but it has been short-lived. It has been difficult for the individual investor to keep pace with professional traders during the trading renaissance. This combination, however, of inexpensive computing power, sophisticated software, and a growing body of trading methods continues to make it possible for the knowledgeable investor to design and to test trading strategies with, as the pros like to call it, *a positive expectancy*, or as we call it, the potential for trading profit.

These strategies can be on a par with, worse than, or better than those of many professional investment firms. There is nothing to prevent the individual trader working on his own from creating very sophisticated and successful trading strategies. The technology, price history, and the software are all available. In fact, the capabilities of the contemporary investor equipped with testing software and a powerful computer (circa 2007) far exceeds that of the professional strategist working in 1990. In addition to those increased capacities, the availability, range, and sophistication of current technical analytical methods are also many times greater.

A thorough and comprehensive working knowledge of how to properly design and test strategies, however, has never been more important than it is in today's extremely competitive markets. I am also sorry to say that the strategy development software arena available to the individual trader has, for the most part, not kept pace with this growth in computing power,

software, and technical methods. The life cycle of a successful trading strategy begins as a "twinkle in the strategist's eye" and ends in cash trading profits. This book presents the techniques required to successfully test, optimize, and trade mechanical strategies.

The benefit of a successfully tested mechanical strategy is obvious—financial gain. The drawbacks of an improperly tested strategy, however, are many. The primary one is financial loss, sometimes as extreme as financial ruin. To add insult to financial injury, these trading losses are often preceded by hundreds of hours of labor and the attendant frustration and disappointment that naturally follow from such a failure.

The trader who diligently applies the procedures provided herein to the development and evaluation of his trading strategy will be able to avoid these costly pitfalls.

WHY THIS BOOK WAS WRITTEN

This book was written to provide a clear-cut and specific road map for the trader who wants to transform a trading idea into a tested, verified, properly capitalized, and profitable automated trading strategy.

The use of technical analysis and trading strategies has become so widespread in the futures trading space that it is now the dominant form of trading by most professionals, and the sophistication and the range of methods just continues to grow. The penetration of many of the types of trading strategies that are pervasive in the futures space, however, is far more limited in the equities and hedge fund spaces.

As the remarkable returns of the rocket-scientists-turned-top-algorithmic traders such as Jim Simons (Renaissance Technologies), David Shaw (D.E. Shaw & Company), and Doyne Farmer (The Prediction Company) have shown, those in these spaces have certainly developed their own original, sophisticated, and extremely effective approach to trading strategies. Interest in the approaches of the futures trading space is also growing in the equities space.

By their very nature, numeric, systematic, and automatic approaches to trading lend themselves to computerized testing. If done correctly, testing can add tremendous value to a trading strategy. In fact, I, and the trading programs at Pardo Capital Limited, would never trade with a strategy that did not prove itself through some form of comprehensive, systematic testing.

Strategy development and testing done incorrectly will lead to real-time trading losses. Make no mistake about this consequence. As the famous computer saying goes, "Garbage in, garbage out." Consequently, because of the inevitable results that follow error, poor procedure, and

shoddy craftsmanship, computer testing is best done properly or not done at all.

Because of ignorance of proper testing procedures, some traders have become disillusioned with the very idea of computer testing. Poor craftsmanship in trading strategy development has even led some traders to believe that trading strategies don't work.

Because of ignorance and the difficulties of performing optimization and back-testing correctly, some still believe that testing and optimization are little more than an exercise in curve-fitting. For those of you who are unfamiliar with these terms, don't worry, they are all formally defined in the appropriate chapters.

The procedures and methods presented in this book prove that the benefits of correct testing and optimization vastly outweigh the effort required to learn and to master their proper application. The procedures mapped out in this book set forth in detail the correct way to formulate, test, and optimize a trading strategy.

To set the record straight, this book makes a clear and unambiguous distinction between the terms *optimization* and *overfitting*. Optimization refers to the process whereby a trading strategy is tested and refined so as to produce the best possible real-time trading profits. Optimization then is testing done *correctly*. Overfitting, which no sane strategist ever does intentionally, is optimization that has gone bad. Overfitting, then, is *incorrect* testing.

WHO WILL BENEFIT FROM THIS BOOK?

I hope that this book will provide value for anyone planning to employ mechanical strategies in her trading. It presents, from start to finish, the methods that must be employed to obtain and enjoy the fruits of a profitable trading strategy.

A thorough review of strategy testing highlights one of its greatest benefits: the precise measurement of reward and risk. The value of a trading strategy must be evaluated in two interrelated dimensions: profit and risk. One cannot judge these two components of trading performance in isolation. Trading always involves risk. Trading profit can be correctly evaluated only with respect to its risk, which is its major cost.

A trading strategy, therefore, can be evaluated properly only when profit and risk have been measured precisely and accurately, which can best be done through computerized testing. This absolute necessity of the accurate measurement and correct evaluation of risk and reward alone would be sufficient unto itself to justify the computer testing of a trading strategy.

Perhaps the other, and perhaps the greatest benefit, of trading with an objective, consistent, reproducible, and thoroughly understood automated strategy is the subsequent elimination of human emotion and fallible human judgment from the trading equation.

Whether or not you consider yourself a systematic trader, if you succeed at trading and have done so for some years, the odds are that you trade systematically with a perhaps very complex trading strategy formulated over years of trading.

If you have not already done so, I would urge you to make every effort to extract your trading strategy from the confines of your brain cells and reproduce it in a form that is amenable to some form of testing.

I believe, therefore, that this book holds value for any trader, mechanized, computerized, or not. It comprehensively presents the case for the benefits and necessity of the proper testing of a clearly specified trading strategy. A careful study and application of the methods presented herein will hopefully further refine and enhance the reader's computerized trading skills. Perhaps the noncomputerized trader will acquire an appreciation for the many benefits of this approach to trading and strategy development. Moreover, the noncomputerized trader may finally recognize the benefits of a thoroughly researched analysis of her strategy and make a start with the application of these methods to her advantage.

If you are a trader who is using computerized trading strategies but are not trading profitably, you should definitely read this book. You will most likely find out where you have gone wrong. At that point, you can determine whether you can repair your strategy or not.

More important, if you want to begin strategy development, this book is an excellent place to start. A study of the guidelines presented herein will help identify and eliminate the causes of failure, such as a poor strategy, improper testing methodology, or incorrect real-time interpretation.

I also, and this may surprise some, recommend this book for those traders who wish to pursue the path of discretionary, as in nonsystematic, trading. After studying this material, you will at least be advised of some things to look for in your trading so you can make every effort to both balance risk and reward and be properly capitalized.

Again, at the risk of sounding presumptuous, I also hope that this book will help those computerized trading strategists out there who have been enjoying trading profit as a result of their work. I present a number of testing guidelines here for the first time. The systematic and comprehensive procedures mapped out here are very efficient and effective. I also know that this overall approach is not too widely practiced by many strategists.

I also hope that the detailed presentation of Walk-Forward Analysis, fully detailed in Chapter 11: Walk-Forward Analysis, will bring this

powerful methodology and its benefits before the eyes of those who will use it to further enhance their trading profit.

THE GOALS OF THIS BOOK

This book will present, explain, clarify, and illustrate:

- The many advantages that follow from the use of a properly developed automated trading strategy
- How to formulate, test, and evaluate a trading strategy
- How to properly optimize a trading strategy
- The symptoms of overfitting and guidelines to avoid it
- How to incorporate out-of-sample data in the testing of a strategy
- The benefits of and how to do a Walk-Forward Analysis
- How to develop a trading strategy profile
- How to judge real-time trading performance with respect to the trading strategy profile developed through historical testing

I have practiced these principles of trading strategy development presented in this book for years. As such, it is fair to say that they have passed my tests of time and of success in real-time trading.

Of course, there are some refinements and trade secrets that I do not disclose. I can say, however, that if a trading idea has initial merit, then a diligent application of the principles disclosed in this book will produce tradable strategies performing at optimal levels.

If you are new to trading strategy development, I would encourage you to master these principles and put them to the test. In all likelihood, you will save yourself a lot of wasted time, a great deal of grief and frustration, and probably a good deal of money.

You can certainly learn something from this book unless you already know how to effectively apply some form of Walk-Forward Analysis (WFA). It has been my experience that WFA is the only nearly fool-proof method (nothing in trading is 100 percent) of trading strategy optimization. Although some might disagree, I suggest that you put it to the test before forming an opinion about it.

THE LAY OF THE LAND

Everything created under the sun began as an idea. Most ideas are a bit vague when first conceived. As the idea is further explored, however, it gradually gains a more precise form. Once fully formulated and visualized,

it takes on a definite and specific form and when formulated in such a way, an idea is capable of becoming a concrete, manifest reality. The same holds true for a trading strategy.

Chapter 2: *The Systematic Trading Edge* presents the benefits, along with some drawbacks, of trading with a computer-tested automatic trading strategy. This unfolds in three parts, detailing the benefits, respectively, of a trading strategy, the historical simulation, and strategy optimization.

A mechanical trading strategy, called simply a *trading strategy*, or *strategy*, is a set of objective and formalized rules external to and independent of the mind and emotions of the trader. The majority of successful traders employ a consistent set of rules, whether or not they are overtly formulated and tested as a formal trading strategy. The use of a consistent set of trading rules is essential to the management of risk and to the creation of trading profit.

After a reading of this chapter, those who still decline to use automated trading strategies will at least know what they are missing. Those who embrace automated trading will rest assured of the merit of the approach. I hope it will provoke those who are still undecided to explore the potential of the automated and tested trading strategy.

Chapter 3: *The Trading Strategy Development Process* maps out the steps through which a trading strategy must evolve, beginning with formulation and precise specification, testing, optimization by way of Walk-Forward Analysis, and culminating in real-time trading. The chapter structure of this book follows this process in its natural order. Essential background material is introduced and interspersed within this overall process, however, as and when it is needed.

Chapter 4: *The Strategy Development Platform* is a brief overview of what the capabilities of a trading strategy development and testing application must include to effectively complete the entire testing cycle from idea to portfolio. A full survey of the plethora of trading development platforms is beyond the scope of this book. It therefore focuses on the various aspects that constitute the full evaluation and development style and what is therefore the minimum feature set needed to complete the process. This chapter also outlines the various processes that need to be completed to take a trading strategy from an idea to an automated, multimarket, multiple time frame trading platform.

Chapter 5: *The Elements of Strategy Design* is an overview of the principles of trading strategy design. Since a full exposition of the principles of strategy design is beyond the scope of this book, the chapter focuses on the essentials of design and the impact that different types of strategies can have on the testing process. It provides the reader with a broad overview of a trading strategy's various components and their purposes.

It also provides a platform and basic foundation for those wishing to enhance their knowledge of this subject.

The prudent, experienced, and well-informed trader is well aware that it is a great deal cheaper and much easier on the nerves, emotions, and confidence to evaluate the performance and value of a trading system using a historical computer simulation. The alternative, of course, is to just start trading with capital and see how things turn out, but that is likely to prove costly.

Chapter 6: *The Historical Simulation* describes what a historical simulation is and what it looks like. The chapter details the various issues that one must address to achieve the most accurate, authentic, and realistic simulation possible of trading with a strategy based on historical data. This approach to the evaluation of a trading strategy is so commonly practiced and widely accepted that I can hardly imagine how anyone ever traded without this process.

Chapter 7: *Formulation and Specification* goes into sufficient detail to clarify the central importance of this first stage in the strategy development process. It provides an illustration of the process of transforming a vague trading concept into computer-testable code.

Chapter 8: *Preliminary Testing* outlines the procedures to be employed in the first round, or preliminary stage, of trading strategy testing. The first step, of course, is to determine whether the strategy has been correctly specified. The next step is to simulate the strategy over a number of small, representative baskets of markets and a diverse set of discrete time periods.

Chapter 9: *Search and Judgment* explores the practical impacts strengths and weaknesses of different types of search and evaluation methods have upon the outcome and quality of the historical simulation and on the optimization processes.

The type of search method employed will determine the amount of processor time necessary to complete the required research. The type of objective function used during the optimization will have a large-to-dominant impact upon the quality of the resulting models. This chapter demonstrates the paramount importance of the objective function. The correct objective function is also one of the keys to the identification of robust trading models and is central to the effective application of Walk-Forward Analysis.

The model parameters selected during the optimization of a trading strategy are based on an objective function also known as *optimization function* and *search parameter*. There's a wise saying that goes "Be careful of what you wish for because you just might get it." This is never truer than in optimization. Optimization and simulation work by their nature are computationally intensive. Extensive literature has been devoted to the multitude of methods available to search through a large number of

simulations to identify the optimal and robust parameter values. The goal of these various objective functions or search methods is to identify the most robust model parameters while still keeping the required processing time to a minimum. This chapter also demonstrates the central importance of the objective function to optimization and also to Walk-Forward Analysis.

Many trading strategies have rules and formulas that can accept different numerical values. These parameter values may vary with different types of markets and conditions. Such a trading strategy may often benefit from optimization. If the trading strategy is found to be satisfactory at the end of this first stage of testing, it is time to move on to the second round of testing, which is optimization.

Chapter 10: *Optimization* presents the proper methods to optimize a trading system. Optimization proceeds through two levels. The first is an optimization of the trading strategy over a variety of different markets and time periods. The main purpose of this stage is to determine to what degree the trading strategy is enhanced by optimization. If the strategy demonstrates better performance under optimization, then it is taken to the final round of optimization and testing: the Walk-Forward Analysis.

Chapter 11: *Walk-Forward Analysis* presents this advanced method of strategy optimization, testing, and validation alongside the three major objectives achieved by Walk-Forward Analysis (WFA). The optimization of the trading strategy under an exhaustive WFA measures the trading performance exclusively on the basis of out-of-sample trading, that is, on data other than those used to optimize the strategy.

The first, and far and away the most important, objective of the WFA is to determine whether the trading strategy remains effective on unseen or out-of-sample price history. This, of course, is one of the most reliable and major predictors of real-time trading success. If it *walks forward* well, as we call it, then it is highly likely that it will continue to perform profitably in real-time trading.

The second and next most important objective of the WFA analysis is to determine the optimal parameter values to be used with real-time trading. The third objective is to determine the sizes of the optimization window and the periodic rate at which the strategy is to be reoptimized.

I first introduced Walk-Forward Analysis to the trading public in the first edition of *The Design, Testing, and Optimization of Trading Systems* in 1991. Experience has only continued to prove its merit in the trading arena as the most cost-effective way of producing robust trading strategies that behave in real-time trading in a manner consistent with their historical simulations. Given its efficiency and practicality, it continues to be a surprise to me that it has not attained widespread acceptance and application.

After a trading strategy has been tested, optimized, and walked forward, it must be evaluated, or judged. It must be judged on its merits as an investment competing for capital with the entire universe of investments. It also must be evaluated in comparison to other available trading strategies on the basis of a statistical analysis and review of its own simulation profile and performance structure.

Chapter 12: *The Evaluation of Performance* presents these two essential, typically underappreciated, and often misunderstood procedures.

The simple truth is that with contemporary trading strategy development software and the modern computer, it has never been easier to perform an optimization of a trading strategy. The *proper* ways, however, to test, optimize, and evaluate a trading strategy are not necessarily well known by all of those in the trading community who use these applications.

It is precisely because it is so easy to perform an optimization but so difficult to evaluate it correctly and then successfully trade it in real time, however, that the reputation of optimization has been unfairly tainted by those ignorant of its correct procedure and evaluation.

In fact, it is because of this widespread misuse of optimization that some still falsely equate the term *optimization* with the term *overfitting*. As we see in Chapter 13, *overfitting* or *curve-fitting* is really optimization done incorrectly, carelessly, or gone wrong in some other way.

Chapter 13: *The Many Faces of Overfitting* puts forth the proposition that the *overfitting* of a trading strategy to historical data occurs when testing and optimization are done *incorrectly*. The proper evaluation of an optimization can be a very difficult matter. I personally believe that the most effective way to avoid overfitting during the optimization process is to perform optimization through a Walk-Forward Analysis.[1]

Not all strategists however, have the software necessary to do WFA. The effects of the overfitting or curve-fitting of a trading strategy to its historical data are devastating, and an overoptimized trading strategy often leads to significant and immediate real-time trading losses. To help the strategist avoid overfitting, I dedicate an entire chapter to identifying the symptoms that result from the accidental abuse of proper testing and optimization methods.

This chapter also includes an extensive discussion of a variety of methods designed to detect and avoid curve-fitting, including the most effective way to do this, which is to include out-of-sample testing in your optimization process.

The goal of any trading strategy is to enjoy long-lasting, real-time trading profit. Once the full cycle of trading strategy development has been successfully completed—namely, strategy formulation, testing, optimization, walk-forward analysis, and evaluation—then, and only then, can real-time trading safely begin.

Chapter 14: *Trading the Strategy* presents the guidelines one must follow to assess real-time trading performance in the context of the knowledge of profit and risk arrived at by computer testing and formulated in the statistical strategy profile.

The improper evaluation of real-time performance will cause problems for the trading strategist. It is essential to know, within reason, that the carefully and painstakingly developed trading strategy is performing in real-time trading within the bounds of the trading strategy profile. Without this essential knowledge, the strategist is like the captain of a ship at sea without any sort of navigational apparatus.