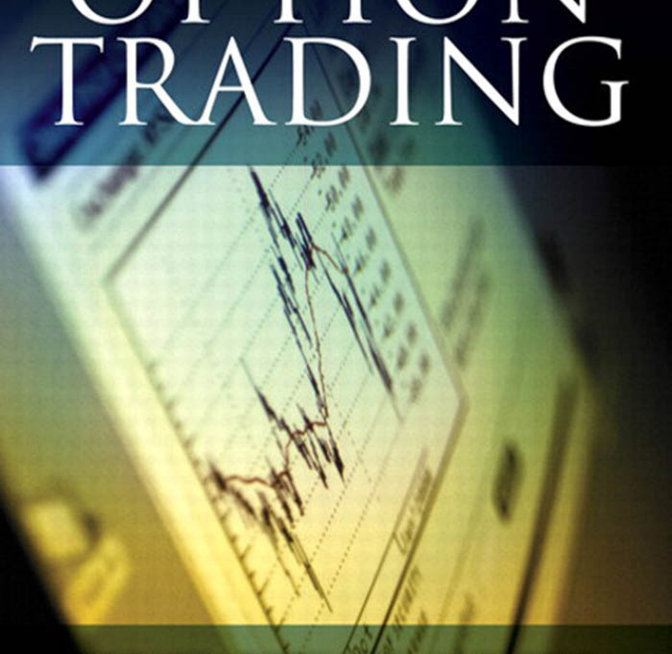
SERGEY IZRAYLEVICH, PH.D. • VADIM TSUDIKMAN

AUTOMATED OPTION TRADING



CREATE, OPTIMIZE, AND TEST AUTOMATED TRADING SYSTEMS

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Test Automated Trading Systems

Sergey Izraylevich, Ph.D., and
Vadim Tsudikman

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This book is dedicated to our parents,
Izraylevich Olga, Izraylevich Vladimir,
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About the Authors

Sergey Izraylevich, Ph.D., Chairman of the Board of High Technology Invest Inc., has traded options for well over a decade and currently creates automated systems for algorithmic option trading. A *Futures* magazine columnist, he has authored numerous articles for highly rated, peer-reviewed scientific journals. He began his career as a lecturer at The Hebrew University of Jerusalem and Tel-Hay Academic College, receiving numerous awards for academic excellence, including Golda Meir's Prize and the Max Shlomiok honor award of distinction.

Vadim Tsudikman, President of High Technology Invest Inc., is a financial consultant and investment advisor specializing in derivatives valuation, hedging, and capital allocation in extreme market environments. With more than 15 years of option trading experience, he develops complex trading systems based on multicriteria analysis and genetic optimization algorithms.

Izraylevich and Tsudikman coauthored *Systematic Options Trading* (FT Press) and regularly coauthor *Futures* magazine articles on cutting-edge issues related to option pricing, volatility, and risk management.

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Introduction

This book presents a concept of developing an automated system tailored specifically for options trading. It was written to provide a framework for transforming investment ideas into properly defined and formalized algorithms allowing consistent and disciplined realization of testable trading strategies.

Extensive literature has been published in the past decades regarding systematic, algorithmic, automated, and mechanical trading. In the Bibliography of this book, we list some of the comprehensive works that deserve special attention. However, all books dedicated to the creation of automated trading systems deal with traditional investment tools, such as stocks, futures, or currencies. Although the development of options-oriented systems requires accounting for numerous specific features peculiar to these instruments, automated trading of options remains beyond the scope of professional literature. The philosophy, logic, and quantitative procedures used in the creation of automated systems for options trading are completely different from those used in conventional trading algorithms. In fact, all the components of a system intended for automated trading of options (strategy development, optimization, capital allocation, risk management, backtesting, performance measurement) differ significantly from their analogs in the systems intended for trading of plain assets. This book describes consecutively the key stages of creating automated systems intended specifically for options trading.

Automated trading of options represents a continuous process of valuation, structuring, and long-term management of investment portfolios (rather than individual instruments). Due to the nonlinearity of options, the expected returns and risks of their complex portfolios cannot be estimated by simple summation of characteristics corresponding to individual options. Special approaches are required to evaluate portfolios containing options (and their combinations) related to different underlying assets. In this book we discuss such approaches, describe systematically the core properties of option portfolios, and consider the specific features of automated options trading at the portfolio level.

An automated trading system represents a package of software modules performing the functions of developing, formalizing, setting up, and testing trading strategies.

Chapter 1, "Development of Trading Strategies," discusses the development and formalization of option strategies. Since there is a huge multitude of trading strategies somehow related to options, we limit our discussion to market-neutral strategies. The reason for selecting this particular type of option strategies relates to its wide popularity among private and institutional investors.

Strategy setup includes optimization of its parameters, capital allocation between portfolio elements, and risk management. Chapter 2, "Optimization," deals with various optimization aspects. In this chapter we discuss various properties of optimization spaces, different types of objective functions and their interrelationships, several methods of multicriteria optimization, and problems of optimization steadiness relative to small changes in the parameters and strategy structure. Special attention is given to the application of traditional methods of parametric optimization to complex option portfolios.

In Chapter 3, "Risk Management," we discuss a set of option-specific risk indicators that can be used for developing a multicriteria risk management system. We investigate the influence of different factors on the effectiveness of the risk indicator and on the number of indicators needed for effective risk measuring.

In Chapter 4, "Capital Allocation and Portfolio Construction," we consider various aspects of capital allocation among the elements of an option portfolio. Capital can be allocated on the basis of different indicators not necessarily expressing return and risk. This chapter describes the step-by-step process of constructing a complex portfolio out of separate option combinations.

The testing of option strategies using historical data is discussed in Chapter 5, "Backtesting of Option Trading Strategies." In this chapter we stress the particularities of creating and maintaining option databases and provide methods to verify data accuracy and reliability. The problem of overfitting and the main approaches to solving it are also discussed. Performance evaluation of option strategies is also the topic of this chapter.

The nature of options makes it possible to create a considerable number of speculative trading strategies. Those can be based on different approaches encompassing the variety of principles and valuation techniques.

In many strategies options are used as auxiliary instruments to *hedge main positions.* In this book we are not going to delve into this field of options application since hedging represents only one constituent part of such trading strategies, but not their backbone.

Options may be used to create *synthetic underlying positions.* In this case the investor aims for the payoff profiles of an option combination and its underlying asset to coincide. This can increase trading leverage significantly. However, apart from leverage, automated trading of synthetic assets is no different from trading in underlying assets (besides the certain specificity regarding execution of trading orders, higher brokerage commissions, and the necessity to roll over positions). Thus, we will not dwell on such strategies either.

Most trading strategies dealing with plain assets (not options) are based on the *forecast of the direction of their price movement* (we will call them *directional strategies*). Options can also be used in such strategies. For example, different kinds of option combinations, commonly referred to as *spreads,* benefit from the increase in the underlying price (bull spreads), or from its decline (bear spread). Despite the fact that trading strategies based on such option combinations possess many features distinguishing them from plain assets strategies, the main determinant of their performance is the accuracy of price forecasts. This quality makes such strategies quite similar to common directional strategies, and therefore we will not consider them in this book.

The focus of this book is on strategies that exploit the specific features of options. One of the key differences of options from other investment assets is the nonlinearity of their payoff functions. In the trading of stocks, commodities, currencies, and other linear assets, all profits and losses are directly proportional to their prices. In the case of options, however, position profitability depends not only on the direction of the price movement, but on many other factors as well. Combining different options on the same underlying asset can bring about almost any form of the payoff function.

This feature of options permits the creation of positions that depend not only on the direction and the amplitude of price fluctuations, but also on many other parameters, including volatility, time left until the expiration, and so forth. The main subject of our consideration is a special type of trading strategies sharing one common property referred to as *market-neutrality.* With regard to options, market-neutrality means that (1) small changes in the underlying price do not lead to a significant change in the position value, and (2) given larger price movements, the position value changes by approximately the same amount regardless of the direction of the underlying price movement. In reality these rules do not always hold, but they serve as a general guideline for a trader striving for market-neutrality. The main analytical instrument used to create market-neutral positions is delta. The position is market-neutral if the sum of the deltas of all its components (options and underlying assets) is equal to or close to zero. Such positions are referred to as *delta-neutral.*

Another type of trading strategy that will be considered in this book is a set of market-neutral strategies whose algorithms contain certain directional elements. Although in this case positions are created while taking into consideration the value of delta, its reduction to zero is not an obligatory requirement. Forecasts of the directions of future price movements represent an integral part of such a strategy. These forecasts can be incorporated into the strategy structure in the form of biased probability distributions or asymmetrical option combinations, or by application of technical and fundamental indicators. We will call such strategies *partially directional.*

Generally, automated strategies are designed to trade one or just a few financial instruments (mainly futures on a given underlying asset). Even if several instruments are traded simultaneously, in most cases positions are opened, closed, and analyzed independently. Options are no exception. Most traders develop systems oriented solely at trading OEX (options on S&P 100 futures) or options on oil futures. In this book we will consider strategies intended to trade an *unlimited number of options relating to many underlying assets.* All positions created within one trading strategy will be *evaluated and analyzed jointly as a whole portfolio.*

Scientific and Empirical Approaches to Developing Automated Trading Strategies

There are two main approaches to the development of automated trading strategies. The first approach is based on the principles and concepts defined by a strategy developer. All the elements composing such a strategy originate from economic knowledge, fundamental estimates, expert opinions, and so forth. Formalization of such knowledge, estimates, and assumptions in the form of algorithmic rules provides a basis for creating an automated trading strategy. Following the example of Robert Pardo, we will call this a *scientific approach.*

At its extreme, the scientific approach provides for a total rejection of optimization procedures. All the rules and parameters of a trading system are determined solely on the basis of knowledge and forecasts of the developer. Apparently, the likelihood of creating a profitable strategy, while avoiding engagement in optimization procedures, is extremely low. Scientific approach in its pure form is hardly applicable in real trading.

The alternative approach is based on the complete denial of any a priori established theories, models, and principles while developing automated trading strategies. This approach requires extensive use of computer technologies to search for profitable trading rules. All algorithms can be tested for this task (with no concern for any economically sound reasons standing behind their application). Candidate algorithms can be selected from a number of ready-made alternatives available or actually constructed by the system developer. The method of algorithm creation is not determined by preliminary assumptions and is not limited by any exogenous reasoning. Trading rules are selected solely on the basis of their testing using historical data. The resulting strategy is devoid of any behavioral logic or economic sense. Following Robert Pardo, we will call it an *empirical approach.*

At its extreme, the empirical approach is a purposeful quest for algorithms and parameters that maximize simulated profit (minimize loss or satisfy any other utility function). This approach is based exclusively on optimization. Nowadays there is a wide choice of high-technology software that facilitates fast development of effective algorithms and provides for establishment of optimal parameter sets. For example, neuron networks and genetic methods represent powerful tools that enable relatively fast finding of optimal solutions through the creation of self-learning systems.

Usually trading strategies constructed on the basis of the empirical approach show remarkable results when tested on historical time series, but demonstrate failure in real trading. The reason for this is overfitting. Even walk-forward analysis does not eliminate this threat because the significant number of degrees of freedom (which is not unusual under the empirical approach) allows choosing such a set of trading rules and parameters that would generate satisfactory results not only during the optimization period, but in the walk-forward analysis as well (we will examine this in detail in Chapter 5). Thus, practical use of the empirical approach exclusively is risky and hardly applicable in real trading.

Rational Approach to Developing Automated Trading Strategies

Most developers of automated trading strategies combine scientific methods and empirical approaches. On the one hand, strategies resulting from such combining are based on strong economic grounds. On the other hand, they benefit from the numerous advantages of optimization and from the impressive progress in computer intelligence. We will call this the *rational approach*.

Under the rational approach a set of rules, determining the general structure of a trading strategy, is formed at the initial stage of strategy creation. These rules are based on the prior knowledge and assumptions about market behavior. The results of statistical research, either received by the strategy developer or obtained from scientific publications and private sources, can also be used to shape the general framework. Obviously, patterns established during such research introduce certain logic into the strategy under development. At the same time, statistical research may result in the discovery of inexplicable relationships lacking any economic sense behind them. Such relationships should be treated with special care since they may either be random in nature or result from data mining.

The initial stage of strategy creation is based mainly on the elements of scientific approach. At this stage the following must be determined:

- Principles of generating the signals for opening and closing trading positions
- Indicators used to generate open and close signals
- A universe of investment assets that are both available and suitable for trading
- Requirements to the portfolio and restrictions imposed on it
- Capital allocation among different portfolio elements
- Methods and instruments of risk management

At the next stage of developing a trading strategy, the rules laid down on the basis of scientific approach are formalized in the form of computable algorithms. This stage is congested with elements of the empirical approach. These are the essential steps:

- Defining specific parameters. All rules formulated on the basis of the scientific approach should be formalized using a certain number of parameters.
- Specifying the algorithms for parameter calculation. Different algorithms may be invented for calculating the same parameter.
- Establishing the procedures for the selection of parameter values. This requires adopting a certain optimization technique.

Usually the decision on the number of parameters and selection of methods for their optimization does not depend on the economic considerations of the developer, but follows from the specific requirements to the strategy and from its technical constraints. These requirements and constraints are developed with regard to the reliability, stability, and other strategy features, among which the capability to avoid the overfitting is one of the most important properties.

In this book we will follow the principles of rational approach to the creation of trading strategies. The main task of the developer is to combine methods attributed to the scientific and the empirical approaches in a reasonable and balanced manner. In order to accomplish this task successfully, all basic components of a trading strategy should be clearly identified as belonging either to components that are set on the basis of well-founded reasoning or to an alternative category of components that are formed primarily by applying various optimization methods.

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