AUTOMATED OPTION TRADING

CREATE, OPTIMIZE, AND TEST AUTOMATED TRADING SYSTEMS
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Create, Optimize, and Test Automated Trading Systems

Sergey Izraylevich, Ph.D., and Vadim Tsudikman
This book is dedicated to our parents,
Izraylevich Olga, Izraylevich Vladimir,
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Contents

Introduction ......................................................... xv

Chapter 1 Development of Trading Strategies ................. 1

1.1 Distinctive Features of Option Trading Strategies .... 1
  1.1.1 Nonlinearity and Options Evaluation ............. 1
  1.1.2 Limited Period of Options Life ................... 2
  1.1.3 Diversity of Options ................................. 3

1.2 Market-Neutral Option Trading Strategies ............. 4
  1.2.1 Basic Market-Neutral Strategy ................... 4
  1.2.2 Points and Boundaries of Delta-Neutrality ....... 6
  1.2.3 Analysis of Delta-Neutrality Boundaries .......... 10
  1.2.4 Quantitative Characteristics of Delta-Neutrality
        Boundaries ........................................... 14
  1.2.5 Analysis of the Portfolio Structure ............. 21

1.3 Partially Directional Strategies ........................ 34
  1.3.1 Specific Features of Partially Directional
        Strategies ........................................... 35
  1.3.2 Embedding the Forecast into the Strategy
        Structure ............................................ 36
  1.3.3 The Call-to-Put Ratio at the Portfolio Level .... 40
  1.3.4 Basic Partially Directional Strategy ............. 42
  1.3.5 Factors Influencing the Call-to-Put Ratio in an
        Options Portfolio ................................. 44
  1.3.6 The Concept of Delta-Neutrality as Applied
        to a Partially Directional Strategy ............... 49
  1.3.7 Analysis of the Portfolio Structure ............. 57
1.4 Delta-Neutral Portfolio as a Basis for the Option Trading Strategy ........................................ 61

1.4.1 Structure and Properties of Portfolios Situated at Delta-Neutrality Boundaries .......... 62

1.4.2 Selection of an Optimal Delta-Neutral Portfolio ................................................................. 67

Chapter 2 Optimization ................................................................. 73

2.1 General Overview ................................................................. 73

2.1.1 Parametric Optimization ................................................. 73

2.1.2 Optimization Space ............................................................ 75

2.1.3 Objective Function ............................................................. 78

2.2 Optimization Space of the Delta-Neutral Strategy ......................................................... 79

2.2.1 Dimensionality of Optimization ........................................ 80

2.2.2 Acceptable Range of Parameter Values ................................ 85

2.2.3 Optimization Step .............................................................. 87

2.3 Objective Functions and Their Application ................................................................. 88

2.3.1 Optimization Spaces of Different Objective Functions .............................................. 89

2.3.2 Interrelationships of Objective Functions ................................................................. 91

2.4 Multicriteria Optimization ............................................................. 96

2.4.1 Convolution ........................................................................ 97

2.4.2 Optimization Using the Pareto Method ................................................................. 99

2.5 Selection of the Optimal Solution on the Basis of Robustness ....................................... 102

2.5.1 Averaging the Adjacent Cells ............................................... 103

2.5.2 Ratio of Mean to Standard Error ........................................ 104

2.5.3 Surface Geometry ............................................................ 106

2.6 Steadiness of Optimization Space ........................................................................ 108

2.6.1 Steadiness Relative to Fixed Parameters ............................................. 109

2.6.2 Steadiness Relative to Structural Changes .............................................. 110

2.6.3 Steadiness Relative to the Optimization Period ........................................ 112
Chapter 4  One-Dimensional System of Capital Allocation

4.4 One-Dimensional System of Capital Allocation

4.4.1 Factors Influencing Capital Allocation

4.4.2 Measuring the Capital Concentration in the Portfolio

4.4.3 Transformation of the Weight Function

4.5 Multidimensional Capital Allocation System

4.5.1 Method of Multidimensional System Application

4.5.2 Comparison of Multidimensional and One-Dimensional Systems

4.6 Portfolio System of Capital Allocation

4.6.1 Specific Features of the Portfolio System

4.6.2 Comparison of Portfolio and Elemental Systems

4.7 Establishing the Capital Allocation System: Challenges and Compromises

Chapter 5  Backtesting of Option Trading Strategies

5.1 Database

5.1.1 Data Vendors

5.1.2 Database Structure

5.1.3 Data Access

5.1.4 Recurrent Calculations

5.1.5 Checking Data Reliability and Validity

5.2 Position Opening and Closing Signals

5.2.1 Signals Generation Principles

5.2.2 Development and Evaluation of Functionals

5.2.3 Filtration of Signals

5.3 Modeling of Order Execution

5.3.1 Volume Modeling

5.3.2 Price Modeling

5.3.3 Commissions
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.4 Backtesting Framework</td>
<td>232</td>
</tr>
<tr>
<td>5.4.1 In-Sample Optimization and Out-of-Sample Testing</td>
<td>232</td>
</tr>
<tr>
<td>5.4.2 Adaptive Optimization</td>
<td>233</td>
</tr>
<tr>
<td>5.4.3 Overfitting Problem</td>
<td>234</td>
</tr>
<tr>
<td>5.5 Evaluation of Performance</td>
<td>236</td>
</tr>
<tr>
<td>5.5.1 Single Event and Unit of Time Frame</td>
<td>236</td>
</tr>
<tr>
<td>5.5.2 Review of Strategy Performance Indicators</td>
<td>237</td>
</tr>
<tr>
<td>5.5.3 The Example of Option Strategy Backtesting</td>
<td>242</td>
</tr>
<tr>
<td>5.6 Establishing the Backtesting System: Challenges and Compromises</td>
<td>246</td>
</tr>
<tr>
<td>Bibliography</td>
<td>247</td>
</tr>
<tr>
<td>Appendix</td>
<td>251</td>
</tr>
<tr>
<td>Basic Notions</td>
<td>251</td>
</tr>
<tr>
<td>Payoff Functions</td>
<td>254</td>
</tr>
<tr>
<td>Separate Options</td>
<td>254</td>
</tr>
<tr>
<td>Option Combinations</td>
<td>255</td>
</tr>
<tr>
<td>Index</td>
<td>261</td>
</tr>
</tbody>
</table>
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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.

The Book Structure

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.

**Strategies Considered in This Book**

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.
Index

A

acceptable values, determining range of, 76, 85-87
access in historical database (in backtesting systems), 220-221
adaptive optimization, 233-234
additive convolution, 97, 172
adjacent cells, average of, 103-104
alternating-variable ascent optimization method, 116-118
comparison with random search method, 132
effectiveness of, 128
American option, defined, 251
amoeba search optimization method, 123-127
analysis of variance (ANOVA) in one-dimensional capital allocation system, 190-191
analytical method (index delta calculation), 142-143
analytical method (VaR calculation), 137
arbitrage situations, tests for, 223
assets
in delta-neutral strategy, 5
in portfolio
analysis of delta-neutrality strategy, 24-25
analysis of partially directional strategies, 58
price forecasts, 35
call-to-put ratio in portfolio, 40-49
delta-neutrality applied to, 49-57
embedding in strategy structure, 36-40
asymmetry coefficient, 157-159, 180-181
asymmetry of portfolio
  analysis of delta-neutrality strategy, 29-30
  analysis of partially directional strategies, 60
at-the-money, defined, 252
attainability of delta-neutrality, 14, 19-20, 51, 54-55
automated trading systems
  defined, xv
  empirical approach to development, xviii-xix
  rational approach to development, xix-xx
  scientific approach to development, xviii
average of adjacent cells, 103-104
B
backtesting systems
  challenges and compromises, 246
  framework for, 232
    adaptive optimization, 233-234
    in-sample optimization/out-of-sample testing, 232-233
    overfitting problem, 234-236
historical database, 217
  data access, 220-221
  data reliability/validity, 222-224
  data vendors for, 218
  recurrent calculations, 221-222
  structure of, 219-220
order execution simulation, 228
  commissions, 231
  price modeling, 230-231
  volume modeling, 229
performance evaluation indicators, 236
  backtesting example, 242-245
  characteristics of return, 237-238
  consistency, 241
  maximum drawdown, 238-239
  profit/loss factor, 240-241
  Sharpe coefficient, 239-240
  single events, 236
  unit of time frame, 236
signals generation, 225
  filtration of signals, 227-228
  functionals development/evaluation, 226-227
  principles of, 225-226
bear spreads, payoff functions, 258-259
boundaries of delta-neutrality, 6-10
  in calm versus volatile markets, 10-11, 13
optimal portfolio selection, 67-72
  in partially directional strategies, 49-55, 57
portfolio structure and properties at, 62-65
quantitative characteristics of, 14-21
broker commissions (in backtesting systems), 231
bull spreads, payoff functions, 258-259

calendar optimization, defined, 73
calendar spreads, payoff functions, 257-258
call options
  defined, 251
  payoff functions, 254-255
call-to-put ratio in portfolio, 40-42
  factors affecting, 44-49
calm markets
  delta-neutrality boundaries in, 10-13, 51-52
  portfolio structure analysis
    long and short combinations, 26-27
    loss probability, 31-33
    number of combinations in portfolio, 22-24
    number of underlying assets in portfolio, 24-25
    portfolio asymmetry, 29-30
    straddles and strangles, 28-29
    VaR, 33-34
capital allocation
  challenges and compromises, 214-216
  classical portfolio theory, 168-169
    option portfolios, features of, 169-170
  in delta-neutral strategy, 5

indicators
  asymmetry coefficient, 180-181
  delta, 180
  expected profit, 179
  inversely-to-the-premium, 175-176
  inversely-to-the-premium versus stock-equivalency, 176-178
  profit probability, 179
  stock-equivalency, 174-175
  VaR, 181-183
  weight function for return/risk evaluation, 178-179

multidimensional system, 172, 204-205
  one-dimensional system versus, 206-209

one-dimensional system, 170, 172
  analysis of variance in, 190-191
  factors affecting, 183-186
  historical volatility in, 186-187
  measuring capital concentration, 192-195
  multidimensional system versus, 206-209
  number of days to expiration in, 187-188
  number of underlying assets in, 188-190
  weight function transformation, 196-204
in partially directional strategies, 43
portfolio system, 209-211
  elemental approach versus, 173-174, 211-214
capital concentration
  concave versus convex weight function comparison, 202-204
  measuring, 192-195
  one-dimensional versus multi-dimensional capital allocation systems, 208-209
  portfolio versus elemental capital allocation systems, 213-214
capital management systems
  first level of, 167
  in partially directional strategies, 43
  second level of, 167
characteristics of return performance indicator, 237-238
classical portfolio theory, 168-169
  option portfolios, features of, 169-170
closing signals
  in delta-neutral strategy, 4
  generating (in backtesting systems), 225
    filtration of signals, 227-228
    functionals development/evaluation, 226-227
    principles of, 225-226
  in partially directional strategies, 42
combination of options, 3
combinations
  defined, 252
  factors affecting call-to-put ratio, 44-49
  long and short combinations,
    analysis of delta-neutrality strategy, 26-27
  in partially directional strategies, 43
payoff functions for, 255
  bull/bear spreads, 258-259
  calendar spreads, 257-258
  straddles, 256
  strangles, 256-257
in portfolio
  analysis of delta-neutrality strategy, 22-24
  analysis of partially directional strategies, 57-59
commissions (in backtesting systems), 231
computation, defined, 74
concave weight function, 196, 198
  convex weight function compared
    by capital concentration, 202-204
    by profit, 200-202
conditional optimization, 74
consistency performance indicator, 241
constraints in conditional optimization, 74
convex weight function, 196-198
concave weight function compared
by capital concentration, 202-204
by profit, 200-202
convolution
of indicators, 172
in multicriteria optimization, 97-98
correlation analysis
of objective functions, 91-96
risk indicator interrelationships, 162-165
correlation coefficient in objective
function relationships, 91
criterion parameters in partially direc-
tional strategies, 42
criterion threshold index, 14-17, 51-52
point of delta-neutrality,
determining, 7-8

D

data access in historical database (in
backtesting systems), 220-221
data reliability in historical database
(in backtesting systems), 222-224
data validity in historical database (in
backtesting systems), 222-224
data vendors for historical database (in
backtesting systems), 218
database (in backtesting systems), 217
data access, 220-221
data reliability/validity, 222-224
data vendors for, 218

recurrent calculations, 221-222
structure of, 219-220
deformable polyhedron optimization
method, 123-127
delta, 138-139, 169, 180, 253. See also
index delta
delta-neutral strategy, xvii, 4
basic form of, 4-5
optimal portfolio selection, 67-72
optimization space of, 79-80
acceptable range of
parameter values, 85-87
optimization dimension-
ality, 80-85
optimization step, 87-88
partially directional strategies
versus, 34
points and boundaries of, 6-10
in calm versus volatile
markets, 10-11, 13
quantitative characteristics
of, 14-21
portfolio structure analysis, 21-34
long and short
combinations, 26-27
loss probability, 31-33
number of combinations in
portfolio, 22-24
number of underlying assets
in portfolio, 24-25
portfolio asymmetry, 29-30
straddles and strangles,
28-29
VaR, 33-34
portfolio structure and properties at boundaries, 62-65
price forecasts versus, 35
delta-neutrality
  applied to partially directional strategies, 49-55, 57
  attainability, 14, 19-20, 51, 54-55
derivatives, Greeks as, 138
determination coefficient in objective function relationships, 91
dimensionality of optimization, 80-85
  one-dimensional optimization, 80-82
  two-dimensional optimization, 83-85
direct filtration method, 227
direct methods, defined, 78
direct search optimization methods, 115
  alternating-variable ascent method, 116-118
  comparison of effectiveness, 127-130
drawbacks to, 115-116
  Hook-Jeeves method, 118-120
  Nelder-Mead method, 123-127
  Rosenbrock method, 120-123
directional strategies, xvi
diversification, underlying assets in portfolio, 24
diversity of options available, 3
domination in Pareto method, 99
elemental capital allocation approach, 173-174
  portfolio system versus, 211-214
embedding price forecasts in strategy structure, 36-40
empirical approach to automated trading system development, xviii-xix
equity curve in backtesting results, 242-244
European option, defined, 251
evaluation
  of option pricing, 1-2
  of performance (in backtesting systems), 236
    backtesting example, 242-245
    characteristics of return, 237-238
    consistency, 241
    maximum drawdown, 238-239
    profit/loss factor, 240-241
    Sharpe coefficient, 239-240
    single events, 236
    unit of time frame, 236
exhaustive search optimization method, 114-115
expected profit (capital allocation indicator), 179
expiration date, 169
  defined, 251
in delta-neutral strategy, 8-13
effect on call-to-put ratio, 48-49
in one-dimensional capital allocation system, 187-188
exponential annual return, 237

F
fair value pricing, determining, 1-2
filtration of signals, 227-228
first level of capital management systems, 167
fixed parameters, steadiness of optimization space, 109-110
forecasts of underlying asset prices, 35
call-to-put ratio in portfolio, 40-42
factors affecting, 44-49
delta-neutrality applied to, 49-57
embedding in strategy structure, 36-40
full optimization cycle, defined, 74
functionals, development and evaluation of, 226-227
fundamental analysis for price forecasts, 35

G
gamma, 138, 253
generating signals in delta-neutral strategy, 4
genetic algorithms, 115
global maximum, defined, 75
Greeks, 169
defined, 253
in risk evaluation, 138-139

H
hedging strategies, xvi
historical database (in backtesting systems), 217
data access, 220-221
data reliability/validity, 222-224
data vendors for, 218
recurrent calculations, 221-222
structure of, 219-220
historical method (VaR calculation), 137
historical optimization period, steadiness of optimization space, 112-114
historical volatility
defined, 252
in delta-neutral strategy, 80
in one-dimensional capital allocation system, 186-187
recurrent calculations applied, 221-222
in risk evaluation, 136
Hook-Jeeves optimization method, 118-120
comparison with random search method, 132
effectiveness of, 128

I–J–K
ideal strategy, 241
implied volatility
defined, 252
estimations, 224
<table>
<thead>
<tr>
<th>Term</th>
<th>Page Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>in-sample optimization</td>
<td>232-233</td>
</tr>
<tr>
<td>in-the-money, defined</td>
<td>252</td>
</tr>
<tr>
<td>index delta</td>
<td>139, 141, 169</td>
</tr>
<tr>
<td>analysis of effectiveness</td>
<td></td>
</tr>
<tr>
<td>at different time horizons</td>
<td>150-156</td>
</tr>
<tr>
<td>in risk evaluation</td>
<td>146-149</td>
</tr>
<tr>
<td>analytical method of calculation</td>
<td>142-143</td>
</tr>
<tr>
<td>applicability of</td>
<td>156-157</td>
</tr>
<tr>
<td>calculation algorithm</td>
<td>141-142</td>
</tr>
<tr>
<td>example of calculation</td>
<td>144-146</td>
</tr>
<tr>
<td>indirect filtration method</td>
<td>227</td>
</tr>
<tr>
<td>interrelationships</td>
<td></td>
</tr>
<tr>
<td>between risk indicators</td>
<td>161</td>
</tr>
<tr>
<td>correlation analysis</td>
<td>162-165</td>
</tr>
<tr>
<td>testing</td>
<td>161</td>
</tr>
<tr>
<td>of objective functions</td>
<td>91-96</td>
</tr>
<tr>
<td>intrinsic value, defined</td>
<td>251</td>
</tr>
<tr>
<td>inversely-to-the-premium (capital allocation indicator)</td>
<td>175-176</td>
</tr>
<tr>
<td>stock-equivalency versus</td>
<td>176-178</td>
</tr>
<tr>
<td>investment assets</td>
<td></td>
</tr>
<tr>
<td>in delta-neutral strategy</td>
<td>5</td>
</tr>
<tr>
<td>in portfolio</td>
<td></td>
</tr>
<tr>
<td>analysis of delta-neutrality strategy</td>
<td>24-25</td>
</tr>
<tr>
<td>analysis of partially directional strategies</td>
<td>58</td>
</tr>
<tr>
<td>price forecasts</td>
<td>35</td>
</tr>
<tr>
<td>call-to-put ratio in portfolio</td>
<td>40-49</td>
</tr>
<tr>
<td>delta-neutrality applied to</td>
<td>49-57</td>
</tr>
<tr>
<td>embedding in strategy structure</td>
<td></td>
</tr>
<tr>
<td>isolines in delta-neutrality boundaries</td>
<td>9</td>
</tr>
<tr>
<td>L</td>
<td></td>
</tr>
<tr>
<td>length of delta-neutrality boundary</td>
<td>14, 17-19, 51-54</td>
</tr>
<tr>
<td>life span of options</td>
<td>2-3</td>
</tr>
<tr>
<td>nature of</td>
<td></td>
</tr>
<tr>
<td>linear annual return</td>
<td>237</td>
</tr>
<tr>
<td>linear assets, options versus</td>
<td>xvii</td>
</tr>
<tr>
<td>linear financial instruments</td>
<td></td>
</tr>
<tr>
<td>nonlinear instruments versus</td>
<td>135</td>
</tr>
<tr>
<td>risk evaluation</td>
<td>136-137</td>
</tr>
<tr>
<td>local maximum, defined</td>
<td>75</td>
</tr>
<tr>
<td>long calendar spreads</td>
<td>258</td>
</tr>
<tr>
<td>long combinations</td>
<td></td>
</tr>
<tr>
<td>analysis of delta-neutrality strategy</td>
<td>26-27</td>
</tr>
<tr>
<td>factors affecting call-to-put ratio</td>
<td>44-49</td>
</tr>
<tr>
<td>in portfolio, analysis of partially directional strategies</td>
<td>58-59</td>
</tr>
<tr>
<td>long options, payoff functions</td>
<td>254-255</td>
</tr>
<tr>
<td>long positions, limitations on</td>
<td>111</td>
</tr>
<tr>
<td>long straddles</td>
<td>256</td>
</tr>
<tr>
<td>long strangles</td>
<td>256</td>
</tr>
<tr>
<td>loss probability</td>
<td>159-160</td>
</tr>
<tr>
<td>analysis of delta-neutrality strategy</td>
<td>31-33</td>
</tr>
<tr>
<td>in portfolio, analysis of partially directional strategies</td>
<td>60</td>
</tr>
</tbody>
</table>
margin requirements, 170, 252
market impact, 230
market volatility, effect on call-to-put ratio, 46-47
market-neutral strategies, 258. See also delta-neutral strategy
market-neutrality, xvii
Markowitz, Harry, 168
maximum drawdown, 238-239
  as objective function
    effect on optimization space, 90
    relationship with percentage of profitable trades, 93
    relationship with profit, 92
mean, ratio to standard error, 104-105
minimax convolution, 97
modeling (in backtesting systems), 228
  commissions, 231
  price modeling, 230-231
  volume modeling, 229
money management in delta-neutral strategy, 5
Monte-Carlo method (VaR calculation), 137
moving averages, compared with average of adjacent cells, 103
multicriteria optimization, 79
  convolution, 97-98
  nontransitivity problem, 96-97
  Pareto method, 99-102
robustness of optimal solution, 102
  averaging adjacent cells, 103-104
  ratio of mean to standard error, 104-105
  surface geometry, 106-108
steadiness of optimization space, 108-109
  relative to fixed parameters, 109-110
  relative to historical optimization period, 112-114
  relative to structural changes, 110-111
multidimensional capital allocation system, 172, 204-205
  one-dimensional system versus, 206-209
multiple regression analysis in one-dimensional capital allocation system, 190-191
multiplicative convolution, 97, 172
Nelder-Mead optimization method, 123-129
neuronets, 115
nodes, defined, 74
nonlinear financial instruments linear instruments versus, 135
risk evaluation, 138-139
risk indicators, 139
  asymmetry coefficient, 157-159
  index delta, 141-157
  interrelationships between, 161-165
  loss probability, 159-160
  VaR (Value at Risk), 140-141
nonlinearity, options evaluation
  and, 1-2
nonmodal optimization, 76
nonmodal optimization space, 82
nontransitivity in multicriteria optimization, 96-97
normalization, 184

O
objective function
  defined, 74
  effect on optimization space, 89-91
  explained, 78-79
  interrelationships of, 91-96
  usage of, 88
one-dimensional capital allocation system, 170-172
  analysis of variance in, 190-191
  factors affecting, 183-186
  historical volatility in, 186-187
  measuring capital concentration, 192-195
  multidimensional system versus, 206-209
  number of days to expiration in, 187-188
number of underlying assets in, 188-190
  weight function transformation, 196-204
one-dimensional optimization, 80-82
opening signals
  in delta-neutral strategy, 4
  generating (in backtesting systems), 225
  filtration of signals, 227-228
  functionals development/evaluation, 226-227
  principles of, 225-226
in partially directional strategies, 42
optimal area, defined, 75
optimal delta-neutral portfolio selection, 67-72
optimal solution
  defined, 75
  robustness of, 82, 102
  averaging adjacent cells, 103-104
  ratio of mean to standard error, 104-105
  surface geometry, 106-108
optimization
  adaptive optimization, 233-234
  challenges and compromises in, 134
  defined, 73
dimensionality of, 80-85
  one-dimensional optimization, 80-82
two-dimensional optimization, 83-85
Index

in-sample optimization, 232-233
multicriteria optimization
  convolution, 97-98
  nontransitivity problem, 96-97
  Pareto method, 99-102
  robustness of optimal solution, 102-108
  steadiness of optimization space, 108-114
objective function
  effect on optimization space, 89-91
  explained, 78-79
  interrelationships of, 91-96
  usage of, 88
parametric optimization,
  explained, 73-75
  terminology, 74-75
optimization methods
  direct search methods, 115
    alternating-variable ascent method, 116-118
    comparison of effectiveness, 127-130
    drawbacks to, 115-116
    Hook-Jeeves method, 118-120
    Nelder-Mead method, 123-127
    Rosenbrock method, 120-123
  exhaustive search, 114-115
  random search, 131-133
optimization space
  defined, 74
  of delta-neutral strategy, 79-80
    acceptable range of parameter values, 85-87
    optimization dimensionality, 80-85
    optimization step, 87-88
  effect of objective functions on, 89-91
  explained, 75-77
  steadiness of, 108-109
    relative to fixed parameters, 109-110
    relative to historical optimization period, 112-114
    relative to structural changes, 110-111
optimization step, 76, 87-88
option combinations
  defined, 252
  factors affecting call-to-put ratio, 44-49
  long and short combinations, analysis of delta-neutrality strategy, 26-27
  in partially directional strategies, 43
  payoff functions for, 255
    bull/bear spreads, 258-259
    calendar spreads, 257-258
    straddles, 256
    strangles, 256-257
in portfolio
  analysis of delta-neutrality strategy, 22-24
  analysis of partially directional strategies, 57-59
option portfolios
  capital allocation indicators
    asymmetry coefficient, 180-181
delta, 180
  expected profit, 179
  inversely-to-the-premium, 175-176
  inversely-to-the-premium versus stock-equivalency, 176-178
  profit probability, 179
  stock-equivalency, 174-175
  VaR, 181-183
  weight function for return/risk evaluation, 178-179
capital allocation systems,
  challenges and compromises, 214-216
features of, 169-170
multidimensional capital allocation system, 172, 204-205
  one-dimensional system versus, 206-209
one-dimensional capital allocation system, 170-172
  analysis of variance in, 190-191
  factors affecting, 183-186
historical volatility in,
  186-187
measuring capital concentration, 192-195
multidimensional capital allocation system versus, 206-209
number of days to expiration in, 187-188
number of underlying assets in, 188-190
weight function transformation, 196-204
portfolio capital allocation system, 209, 211
  elemental system versus, 173-174, 211-214
option strategies, payoff functions for, 255
  bull/bear spreads, 258-259
  calendar spreads, 257-258
  straddles, 256
  strangles, 256-257
option trading strategies
  limited options life span, 2-3
  nonlinearity and options evaluation, 1-2
  option diversity, 3
options, linear assets versus, xvii
order execution simulation (in backtesting systems), 228
  commissions, 231
  price modeling, 230-231
  volume modeling, 229
out-of-sample testing, 232-233
out-of-the-money, defined, 252
overfitting problem, 234-236

**P**

parameter values, determining
acceptable range of, 76, 85-87
parametric optimization, 73-75. See also optimization
Pareto method, 172
  in multicriteria optimization, 99-102
partially directional strategies, xvii
  basic form of, 42-43
  call-to-put ratio, 40-42
    factors affecting, 44-49
delta-neutrality applied to, 49-57
delta-neutrality strategy
  versus, 34
  embedding forecast in strategy structure, 36-40
  features of, 35
  portfolio structure analysis, 57-61
payoff functions
  call-to-put ratio in portfolio, 40-42
    factors affecting, 44-49
defined, 253
  for option combinations, 255
    bull/bear spreads, 258-259
calendar spreads, 257-258
  straddles, 256
  strangles, 256-257
  in option portfolios, 169
  for separate put/call options, 254-255
percentage of profitable trades as objective function
  effect on optimization space, 90
  relationship with maximum drawdown, 93
  relationship with profit, 92
performance evaluation indicators (in backtesting systems), 236
  backtesting example, 242-245
  characteristics of return, 237-238
  consistency, 241
  maximum drawdown, 238-239
  profit/loss factor, 240-241
  Sharpe coefficient, 239-240
  single events, 236
  unit of time frame, 236
points of delta-neutrality, 6-10
  in calm versus volatile markets, 10-11, 13
  quantitative characteristics of, 14-21
polymodal optimization, 76
polymodal optimization space, 82
portfolio asymmetry, analysis of
  partially directional strategies, 60
portfolio capital allocation approach,
  173-174, 209-211
  elemental system versus, 211-214
portfolio construction
  capital allocation indicators
    asymmetry coefficient, 180-181
delta, 180
  expected profit, 179
inversely-to-the-premium, 175-176
inversely-to-the-premium versus stock-equivalency, 176-178
profit probability, 179
stock-equivalency, 174-175
VaR, 181-183
weight function for return/risk evaluation, 178-179
capital allocation systems, challenges and compromises, 214-216
classical portfolio theory, 168-169
option portfolios, features of, 169-170
multidimensional capital allocation system, 204-205
one-dimensional system versus, 206-209
one-dimensional capital allocation system
analysis of variance in, 190-191
factors affecting, 183-186
historical volatility in, 186-187
measuring capital concentration, 192-195
multidimensional system versus, 206-209
number of days to expiration in, 187-188
number of underlying assets in, 188-190
weight function transformation, 196-204
option portfolios
multidimensional capital allocation system, 172
one-dimensional capital allocation system, 170-172
portfolio versus elemental approach to capital allocation, 173-174
portfolio capital allocation system, 209-211
elemental system versus, 211-214
portfolio structure at delta-neutrality boundaries, 62-65
portfolio structure analysis
of delta-neutrality strategy, 21-34
long and short combinations, 26-27
loss probability, 31-33
number of combinations in portfolio, 22-24
number of underlying assets in portfolio, 24-25
portfolio asymmetry, 29-30
straddles and strangles, 28-29
VaR, 33-34
of partially directional strategies, 57-61
position closing signals
  in delta-neutral strategy, 4
  in partially directional strategies, 42

position opening signals
  in delta-neutral strategy, 4
  in partially directional strategies, 42

position opening/closing signals, generating (in backtesting systems), 225
  filtration of signals, 227-228
  functionals development/evaluation, 226-227
  principles of, 225-226

premium
  defined, 251
  inversely-to-the-premium (capital allocation indicator), 175-176
    stock-equivalency versus, 176-178

price forecasts, 35
  call-to-put ratio in portfolio, 40-42
    factors affecting, 44-49
    delta-neutrality applied to, 49-57
    embedding in strategy structure, 36-40

price modeling (in backtesting systems), 230-231

profit
  concave versus convex weight function comparison, 200-202
  as objective function
    effect on optimization space, 89
    relationship with maximum drawdown, 92
    relationship with percentage of profitable trades, 92
    relationship with Sharpe coefficient, 91
    one-dimensional versus multi-dimensional capital allocation systems, 206-208
    portfolio versus elemental capital allocation systems, 211-213
    profit probability (capital allocation indicator), 179
    profit/loss factor, 240-241

put options
  defined, 251
  payoff functions, 254-255

Q–R

quantitative characteristics of delta-neutrality boundaries, 14-21
quantitative characteristics analysis, 244-245
random search optimization method, 131-133
range of acceptable values, determining, 76, 85-87
rational approach to automated trading system development, xix-xx
recurrent calculations in historical database (in backtesting systems), 221-222
regression analysis, 154
reliability of data in historical database (in backtesting systems), 222-224
requirements in delta-neutral strategy, 5
restrictions in delta-neutral strategy, 5
rho, 138, 253
risk, lack of definition for, 135
risk evaluation
effectiveness of index delta, 146-149
linear financial instruments, 136-137
nonlinear financial instruments, 138-139
risk indicators, 139
asymmetry coefficient, 157-159
establishing risk management systems, 165-166
index delta, 141
analysis of effectiveness at different time horizons, 150-156
analysis of effectiveness in risk evaluation, 146-149
analytical method of calculation, 142-143
applicability of, 156-157
calculation algorithm, 141-142
example of calculation, 144-146
interrelationships between, 161
correlation analysis, 162-165
testing, 161
loss probability, 159-160
VaR (Value at Risk), 140-141
risk management
in delta-neutral strategy, 5
establishing risk indicators, 165-166
the Greeks, 169
in partially directional strategies, 43
robustness of optimal solution, 82, 102
averaging adjacent cells, 103-104
defined, 75
ratio of mean to standard error, 104-105
surface geometry, 106-108
Rosenbrock optimization method, 120-123, 129
rotating coordinates optimization method, 120-123
S
scientific approach to automated trading system development, xviii
second level of capital management systems, 167
selecting optimal delta-neutral portfolio, 67-72
selective convolution, 97
Sharpe coefficient, 239-240
as objective function
effect on optimization space, 90
relationship with profit, 91
short calendar spreads, 257
short combinations
analysis of delta-neutrality strategy, 26-27
factors affecting call-to-put ratio, 44-49
in portfolio, analysis of partially directional strategies, 58-59
short options, payoff functions, 254-255
short straddles, 256
short strangles, 256
signal-generation indicators in delta-neutral strategy, 4
signals generation
in backtesting systems, 225
filtration of signals, 227-228
functionals development/evaluation, 226-227
principles of, 225-226
in delta-neutral strategy, 4
simplex search optimization method, 123-127
simulation of order execution (in backtesting systems), 228
commissions, 231
price modeling, 230-231
volume modeling, 229
single events in performance evaluation, 236
slippage, 230
smoothing, advantages of, 88
smoothness of optimization space, 77
spreads, xvii
standard deviation of asset returns in risk evaluation, 136
standard error, ratio to mean, 104-105
steadiness of optimization space, 77, 108-109
relative to fixed parameters, 109-110
relative to historical optimization period, 112-114
relative to structural changes, 110-111
stock-equivalency (capital allocation indicator), 5, 174-175
inversely-to-the-premium versus, 176-178
straddles
analysis of delta-neutrality strategy, 28-29
payoff functions, 256
strangles
analysis of delta-neutrality strategy, 28-29
payoff functions, 256-257
strike price, defined, 251
strikes range index, 14-17, 51-52
structural changes, steadiness of optimization space, 110-111
structural optimization, defined, 73
surface geometry, determining robustness of optimal solution, 106-108
survival bias problem, 218
synchronization, 219
synthetic assets strategies, xvi
T

technical analysis for price forecasts, 35
testing risk indicator interrelationships, 161. See also backtesting systems
theta, 138, 253
three-dimensional optimization, 77
time decay, defined, 252
time horizons, effectiveness of index delta, 150-156
time value, defined, 252
transformation of weight function, 196-204
transitivity in multicriteria optimization, 96-97
two-dimensional optimization, 77, 83-85

U

unconditional optimization, 74
underlying assets in one-dimensional capital allocation system, 188-190
unimodal optimization, 76
unimodal optimization space, 82
unit of time frame in performance evaluation, 236

V

validity of data in historical database (in backtesting systems), 222-224
Value at Risk. See VaR

values, determining acceptable range of, 76, 85-87
VaR (Value at Risk), 181-183
analysis of delta-neutrality strategy, 33-34
calculation methods, 137
drawbacks to, 140-141
in portfolio, analysis of partially directional strategies, 61
in risk evaluation, 136
variation coefficients, 181, 183
vega, 138-139, 253
vendors for historical database (in backtesting systems), 218
visual analysis of backtesting results, 242-244
volatile markets
delta-neutrality boundaries in, 10-13
delta-neutrality boundaries in partially directional strategies, 51-52
historical volatility in risk evaluation, 136
portfolio structure analysis
long and short combinations, 26-27
loss probability, 31-33
number of combinations in portfolio, 22-24
number of underlying assets in portfolio, 24-25
portfolio asymmetry, 29-30
straddles and strangles, 28-29
VaR, 33-34
volume modeling (in backtesting systems), 229

W–Z
walk-forward analysis, 235
weight function
for return/risk evaluation, 178-179
transformation of, 196-204