Contents

Preface to the second edition  page xi

1 Econophysics: why and what  1
  1.1 Why econophysics?  1
  1.2 Invariance principles and laws of nature  4
  1.3 Humanly invented law can always be violated  5
  1.4 Origins of econophysics  7
  1.5 A new direction in econophysics  8

2 Neo-classical economic theory  10
  2.1 Why study “optimizing behavior”?  10
  2.2 Dissecting neo-classical economic theory (microeconomics)  12
  2.3 The myth of equilibrium via perfect information  18
  2.4 How many green jackets does a consumer want?  24
  2.5 Macroeconomics  25

3 Probability and stochastic processes  29
  3.1 Elementary rules of probability theory  29
  3.2 Ensemble averages formed empirically  30
  3.3 The characteristic function  32
  3.4 Transformations of random variables  33
  3.5 Laws of large numbers  34
  3.6 Examples of theoretical distributions  38
  3.7 Stochastic processes  43
  3.8 Stochastic calculus  57
  3.9 Ito processes  63
  3.10 Martingales and backward-time diffusion  77
### Contents

#### 4 Introduction to financial economics

- 4.1 What does no-arbitrage mean? 80
- 4.2 Nonfalsifiable notions of value 82
- 4.3 The Gambler’s Ruin 84
- 4.4 The Modigliani–Miller argument 85
- 4.5 Excess demand in uncertain markets 89
- 4.6 Misidentification of equilibrium in economics and finance 91
- 4.7 Searching for Adam Smith’s Unreliable Hand 93
- 4.8 Martingale markets (efficient markets) 94
- 4.9 Stationary markets: value and inefficiency 98
- 4.10 Black’s “equilibrium”: dreams of recurrence in the market 101
- 4.11 Value in real, nonstationary markets 102
- 4.12 Liquidity, noise traders, crashes, and fat tails 103
- 4.13 Long-term capital management 105

#### 5 Introduction to portfolio selection theory

- 5.1 Introduction 107
- 5.2 Risk and return 107
- 5.3 Diversification and correlations 109
- 5.4 The CAPM portfolio selection strategy 113
- 5.5 Hedging with options 117
- 5.6 Stock shares as options on a firm’s assets 120
- 5.7 The Black–Scholes model 122
- 5.8 The CAPM option pricing strategy 124
- 5.9 Backward-time diffusion: solving the Black–Scholes pde 127
- 5.10 Enron 2002 130

#### 6 Scaling, pair correlations, and conditional densities

- 6.1 Hurst exponent scaling 133
- 6.2 Selfsimilar Ito processes 135
- 6.3 Long time increment correlations 139
- 6.4 The minimal description of dynamics 145
- 6.5 Scaling of correlations and conditional probabilities? 145

#### 7 Statistical ensembles: deducing dynamics from time series

- 7.1 Detrending economic variables 148
- 7.2 Ensemble averages constructed from time series 149
- 7.3 Time series analysis 152
- 7.4 Deducing dynamics from time series 162
Contents

7.5 Early evidence for variable diffusion models 167
7.6 Volatility measures 167
7.7 Spurious stylized facts 168
7.8 An sde for increments? 173
7.9 Topological inequivalence of stationary and nonstationary processes 173

8 Martingale option pricing 176
8.1 Introduction 176
8.2 Fair option pricing 178
8.3 Pricing options approximately via the exponential density 182
8.4 Option pricing with fat tails 185
8.5 Portfolio insurance and the 1987 crash 186
8.6 Collateralized mortgage obligations 186

9 FX market globalization: evolution of the Dollar to worldwide reserve currency 188
9.1 Introduction 188
9.2 The money supply and nonconservation of money 189
9.3 The gold standard 190
9.4 How FX market stability worked on the gold standard 190
9.5 FX markets from WWI to WWII 194
9.6 The era of “adjustable pegged” FX rates 196
9.7 Emergence of deregulation 197
9.8 Deficits, the money supply, and inflation 204
9.9 Derivatives and shadow banking 208
9.10 Theory of value under instability 211
9.11 How may regulations change the market? 212

10 Macroeconomics and econometrics: regression models vs empirically based modeling 214
10.1 Introduction 214
10.2 Muth’s rational expectations 216
10.3 Rational expectations in stationary markets 219
10.4 Toy models of monetary policy 222
10.5 The monetarist argument against government intervention 224
10.6 Rational expectations in a nonstationary world 225
10.7 Integration I(d) and cointegration 226
10.8 ARCH and GARCH models of volatility 238
11 Complexity

11.1 Reductionism and holism 241
11.2 What does “complex” mean? 244
11.3 Replication, mutations, and reliability 253
11.4 Emergence and self-organization 256

References 261
Index 268