

Contents

List of Boxes	x
List of Figures	xii
Introduction	1
1 Empirical econophysics and stylised facts	7
1.1 Setting the stage	7
1.1.1 A few words on history	7
1.1.2 About efficient markets	10
1.1.3 Stylised facts	16
1.2 Price fluctuations	17
1.2.1 Notation	17
1.2.2 Basic analysis	17
1.2.3 More advanced analysis	22
1.3 Order-book statistics	28
1.3.1 Order placement	28
1.3.2 Price impact	31
1.3.3 Long memory in the order flow	33
1.4 Correlation matrices and economic sectors	34
1.4.1 Hierarchies among stocks	34
1.4.2 Spectrum and localisation	37
1.4.3 Clustering in correlation networks	40
1.5 What remains	42
2 Stochastic models	44
2.1 Random walk and beyond	45
2.1.1 Bachelier's programme	46
2.1.2 Geometric random walk	49
2.1.3 Continuous-time random walk	53
2.2 GARCH and related processes	57
2.2.1 Markovian or not? Bad question	57
2.2.2 Heteroskedasticity	59
2.3 Cascades	65
2.3.1 Motivation	65
2.3.2 Realisation	68
2.4 Stochastic volatility models	78
2.4.1 Systematics	78
2.4.2 Price fluctuation moments	80
2.4.3 Volatility and return distributions	84

2.5	What remains	89
	Problems	91
3	Basic agent models	92
3.1	Aggregation models	92
3.1.1	Economic sandpile	93
3.1.2	Cont-Bouchaud model	100
3.1.3	Eguíluz-Zimmermann model	107
3.2	Agent-based models	113
3.2.1	Early attempts	113
3.2.2	Levy-Levy-Solomon model	124
3.2.3	Lux-Marchesi model	132
3.3	What remains	141
	Problems	143
4	Order-book dynamics	144
4.1	Reaction-diffusion and related processes	145
4.1.1	Instantaneous execution	146
4.1.2	Bak-Paczuski-Shubik model	149
4.2	Reactions of limit and market orders	157
4.2.1	Maslov model	158
4.2.2	Uniform deposition model	163
4.3	Schematic models	165
4.3.1	Interacting gaps	166
4.3.2	Crippled order book	173
4.3.3	Order-book dynamics as a matrix multiplicative process	177
4.4	What remains	182
	Problems	184
5	Minority game	185
5.1	Rules of the game	185
5.1.1	Inductive thinking	185
5.1.2	The algorithm	188
5.1.3	Phase transition	193
5.2	Towards an analytical solution	197
5.2.1	A few modifications	198
5.2.2	Replica solution	201
5.3	Minority game as a market model	210
5.3.1	Producers and speculators	211
5.3.2	Grand-canonical minority game	212
5.4	What remains	217
	Problems	220
6	Network economy	221
6.1	Random graphs	222
6.1.1	About graphs	222
6.1.2	Graph ensembles	225

6.1.3	Graph processes	234
6.2	Statistics of real networks	243
6.2.1	Milgram's letters	244
6.2.2	Degree distributions	245
6.3	Electronic commerce networks	249
6.3.1	Auctions	250
6.3.2	Reviewers' networks	251
6.4	What remains	254
	Problems	256
7	Wealth, poverty, and growth	257
7.1	Laws of Pareto and Gibrat	257
7.1.1	Power-law distribution	257
7.1.2	Independent growth rates	260
7.1.3	Lévy distributions	263
7.2	Individual income	265
7.2.1	Stochastic modelling	265
7.2.2	Many-particle approaches	271
7.2.3	Agent models	273
7.3	Corporate growth	276
7.3.1	Scaling in empirical data	276
7.3.2	Hierarchical model of an organisation	278
7.4	What remains	279
	Problems	281
8	Social organisation	282
8.1	Cooperation	283
8.1.1	Prisoner's dilemma	284
8.1.2	Playing repeatedly	286
8.1.3	Playing in space	296
8.2	Consensus	300
8.2.1	Voter model	300
8.2.2	Galam, Sznajd, and related models	310
8.2.3	Axelrod model	324
8.2.4	Bounded confidence with continuous opinions	335
8.3	Stratification	343
8.3.1	Emerging hierarchies	343
8.3.2	Dynamics of social classes	346
8.4	What remains	348
	Problems	350
	References	352
	Author Index	388
	Subject Index	405