

Contents

Preface	19
Readership to whom this book is addressed	21
Structure of the book.....	23
Recommended courses for the book and suggestions for supporting material.....	24
Contribution and acknowledgements	26
1 Why study other paradigms?	28
1.1 From scepticism to unconditional acceptance	32
1.2 The theory of expected utility as an example of academic inertia	35
1.3 The bases of an alternative paradigm	37
1.4 The importance of using enlightening approaches in the generation of knowledge	43
1.5 Scientific methodologies or rhetorical tools	48
1.6 The advantages of going beyond essays and rhetorical narratives	51
In summary.....	54
Questions for reflection and discussion	54
2 Vision and modelling of complexity	60
2.1 Decentralised processes.....	63
2.2 The premises of an alternative paradigm	67
2.3 Simple rules and self-organisation in complex systems	71
2.4 Examples of local interaction in the natural environment.....	73
2.5 Vehicular traffic as an example of social interaction.....	75
2.6 The effects of interdependence on social segregation	77
2.7 Mass movements of people in public spaces	81
In summary	83
Questions for reflection and discussion	83
3 The dynamics of social phenomena	102
3.1 The importance of history and statistical regularities	105
3.2 The non-linearity of complex adaptive systems	110
3.3 The inductive reasoning of the human being	117
3.4 Methodological co-evolutionism.....	121
In summary	123
Questions for reflection and discussion	123

4	Complexity in economic thought	136
4.1	Some comments on the protohistory of complexity in economics	139
4.2	The mainstream, neoclassical economics and cutting-edge approaches.....	143
4.3	The study of economics and its diverse perspectives	147
4.4	Economic crises and paradigm shifts.....	149
4.5	Macroeconomics as a CAS.....	154
4.6	Public policy in complex adaptive systems	159
	In summary	164
	Questions for reflection and discussion	164
5	Complexity and emerging properties.....	170
5.1	What is a complex adaptive system?.....	173
5.2	Emergent properties.....	179
5.3	The ‘madness (or wisdom) of the masses’ as an example of an emergent property	181
5.4	Phase transitions.....	190
	In summary	198
	Questions for reflection and discussion	198
6	The self-organisation of complexity.....	209
6.1	Evolution as a learning algorithm	213
6.2	The self-organisation of collective behaviour	216
6.3	Between order and chaos	221
6.4	Bak’s sand pile and self-organised criticality	229
6.5	The power law	234
	In summary	239
	Questions for reflection and discussion	239
7	Cellular automata	258
7.1	Topology of interaction.....	261
7.2	1-D cellular automata	264
7.3	The Game of Life.....	267
7.4	The majority game	270
7.5	Probabilistic transition rules.....	272
7.6	Extended neighbourhoods.....	274
7.7	Multivariate cellular automata: the dissemination of culture	275
7.8	Dynamic behaviours and the edge of chaos.....	278
	In summary	290
	Questions for reflection and discussion	290

8 Homo Socialis.....	317
8.1 On the necessity of a historical and contextual meta-theory.....	320
8.2 Evolutionary economics and theories of complexity.....	322
8.3 In search of Homo Socialis.....	326
8.4 Decision making modules	332
In summary	350
Questions for reflection and discussion	350
9 The multifaceted behaviour of human beings.....	377
9.1 The influence of cultural elements.....	380
9.2 Behavioural utility functions, behavioural heuristics and multidimensional motivations.....	386
9.3 The diverse cognitive capacities of software agents	393
9.4 Reductionism and the relative relevance of agency and structure.....	396
9.5 The meta-theory and its links with behavioural economics.....	399
9.6 Laboratory experiments and behaviour in real life.....	402
In summary	407
Questions for reflection and discussion	407
10 Structure and its analytical instrumentation.....	432
10.1 From social capital to social governance	435
10.2 Superficial arenas and institutions	441
10.3 Topology of interaction and social governance.....	447
In summary	458
Questions for reflection and discussion	459
11 Socioeconomic evolution	468
11.1 Darwinian or Lamarckian evolution?	471
11.2 The evolutionary algorithm in the economic arena	477
11.3 Group selection in the socioeconomic CASs.....	484
11.4 Behaviours versus instructions.....	487
11.5 Dynamics of social governance and institutional change.....	491
11.6 Transdisciplinary support for the meta-theory.....	496
In summary	499
Questions for reflection and discussion	499
12 Agent-based computational models	518
12.1 The versatility of algorithmic tools.....	521
12.2 Simplicity or realism of agent-based models?	526

12.3	Simulation as a scientific route for formulating theory.....	529
12.4	Advantages of computational models.....	535
	In summary.....	542
	Questions for reflection and discussion.....	542
13	Three examples of agent-based models.....	559
13.1	Example of an artificial society: <i>Sugarscape</i>	562
13.2	A model of tax collection based on the premises of behavioural economics.....	575
13.3	An agent-based model of fish markets.....	582
	In summary.....	591
	Questions for reflection and discussion.....	591
14	Computational models of networks.....	604
14.1	Theory of graphs and networks.....	607
14.2	The phenomenon of synchronisation.....	611
14.3	Networks with small world architecture.....	617
14.4	The search problem.....	628
	In summary.....	633
	Questions for reflection and discussion.....	634
15	Topology and network formation processes.....	652
15.1	Hierarchical networks.....	655
15.2	The formation of a hierarchical network based on the criterion of popularity.....	659
15.3	Affiliation as a criterion of social distance.....	662
15.4	The self-organisation of a network of creators.....	669
	In summary.....	677
	Questions for reflection and discussion.....	677
16	The dynamics of social diffusion.....	690
16.1	The popularity of cultural goods as an example of social diffusion.....	693
16.2	The different mechanisms of social diffusion and the importance of networks.....	696
16.3	The dynamics of social contagion.....	702
16.4	The diffusion of behaviour via social cascades.....	707
16.5	The dissemination of opinion based on social influence.....	715
16.6	The models of percolation and social diffusion.....	719
	In summary.....	728
	Questions for reflection and discussion.....	728

17	Learning in contexts of uncertainty	745
17.1	The problem of the El Farol bar	748
17.2	The Minority Game	753
17.3	The modelling of learning	756
17.4	Example of learning in an agent-based model	766
	In summary	773
	Questions for reflection and discussion	773
18	Introduction to genetic algorithms	791
18.1	Evolutionary computation	794
18.2	Fitness landscapes	799
18.3	Genetic algorithms	802
18.4	Example one: a sequence of pure ones	807
18.5	Example two: the can collector	808
18.6	An economics application	813
	In summary	820
	Questions for reflection and discussion	821
19	Validation and social mechanisms	835
19.1	Social theories and empirical evidence	838
19.2	The modelling of social mechanisms	843
19.3	The power law and the problem of identification	854
19.4	Formalising the process of validation	857
19.5	Agent-based models as Markovian processes	870
	In summary	878
	Questions for reflection and discussion	879
20	Calibration, verification and replication	897
20.1	Methodologies for the calibration of agent-based models	901
20.2	An example of indirect calibration	914
20.3	The problem of activation	918
20.4	Programme verification procedures	927
20.5	Replicating the outcomes of a computational model	929
20.6	Comparison of ABMs seeking to explain the same phenomenon	934
	In summary	941
	Questions for reflection and discussion	941

21 Empirical applications of social complexity	954
21.1 Economic development from the perspective of complex networks.....	957
21.2 Electoral platforms in a multi-party system	972
21.3 A macroeconomic model with behavioural heuristics.....	984
In summary	998
Questions for reflection and discussion	998
References	1003

Index of boxes

Box 1.1 The development of science	57
Box 1.2 Self-referenced systems and mathematical analysis	59
Box 2.1 The synchronised flight of a flock of birds.....	87
Box 2.2 The self-organisation of an ant colony	89
Box 2.3 Vehicular traffic on a motorway	91
Box 2.4 Vehicular traffic in a city.....	93
Box 2.5 The segregation of communities.....	95
Box 2.6 Circulation of people in public spaces	98
Box 2.7 Evacuations in situations of panic.....	100
Box 3.1 A computational model of the problem of acclamation.....	126
Box 3.2 The difficulty of predicting in a complex world	128
Box 3.3 Strategy design in a complex world	129
Box 3.4 Are human beings truly deductive?	132
Box 3.5 The limitations of methodological individualism	134
Box 4.1 Reflections on the policies promoted by Keynes and Hayek	167
Box 4.2 Reflections on finance policies from the perspective of complexity	168

Box 5.1	Fractal geometry and inequality	201
Box 5.2	Transitory emergent patterns in the game of heroes and cowards	203
Box 5.3	Extensions of the game of heroes and cowards	205
Box 5.4	Phase transitions and crime rate	207
Box 6.1	The evolution of abilities in an ‘artificial world’	243
Box 6.2	The self-replication of a computer programme	245
Box 6.3	The virtual self-organisation of a mucilaginous mould	246
Box 6.4	Boolean networks.....	248
Box 6.5	A technological application of fitness landscapes	250
Box 6.6	A computational model of Bak’s sand pile	252
Box 6.7	Complexity as a historical process	254
Box 6.8	Mathematics of the power law	256
Box 6.9	Graphs of the power law (or Pareto distribution)	257
Box 7.1	Spatio-temporal diagram: Sierpinski’s triangle.....	295
Box 7.2	Three-digit CA with totalistic rules.....	296
Box 7.3	Conway’s Game of Life.....	298
Box 7.4	The game of the majority vote.....	300
Box 7.5	Stochastic 1-D CA.....	302
Box 7.6	A model of rumour propagation	304
Box 7.7	A model of social impact.....	306
Box 7.8	Axelrod’s model of cultural dissemination	308
Box 7.9	1-D categories of cellular automata	310
Box 7.10	Rule codification for 1-D cellular automata.....	312
Box 7.11	The butterfly effect	313
Box 7.12	Bifurcation diagrams	315
Box 8.1	Coinciding views between the Austrian school and theories of complexity	354
Box 8.2	Open and closed systems	356
Box 8.3	Mathematics and the assumptions of neoclassical thinking.....	358
Box 8.4	Examples of the co-evolution between biology and culture	360
Box 8.5	The ultimatum game	362
Box 8.6	The public goods game.....	363
Box 8.7	Work incentives in a game of experimental economics	365
Box 8.8	The gift exchange game	367
Box 8.9	The cognitive revolution and the creation of narratives	369
Box 8.10	Empirical evidence on the effect of empathy on behaviour	371

Box 8.11	The two systems of the cognitive process.....	373
Box 8.12	Social conformity in Asch's experiment.....	375
Box 9.1	Examples of cognitive mechanisms with ideological implications.....	411
Box 9.2	Experimental evidence on the importance of culture in decision making.....	412
Box 9.3	Is utility maximisation a falsifiable hypothesis?.....	414
Box 9.4	Methodological advantages of including moral virtues as social preferences.....	416
Box 9.5	Vehicular traffic under different cognitive capacities.....	418
Box 9.6	A multilateral market with zero-intelligence agents.....	420
Box 9.7	The resilience of heuristics in uncertain environments.....	424
Box 9.8	Anchoring, arbitrary coherence and the fallacy of the laws of supply and demand.....	426
Box 9.9	Procrastination and policy design.....	428
Box 9.10	Realism, environmental control and universal effects.....	430
Box 10.1	Network formation in the context of day nurseries.....	463
Box 10.2	Religions as generators of culture.....	464
Box 10.3	Facebook and social networks.....	466
Box 11.1	Contagion and Lamarckian evolution.....	502
Box 11.2	Generalised Darwinism.....	504
Box 11.3	Evolutionary systems versus creative systems.....	506
Box 11.4	Synergistic effects, competition and group selection.....	508
Box 11.5	Co-evolution between political systems and social norms.....	510
Box 11.6	An example of social change: the collapse of family and community.....	512
Box 11.7	Species propagation via the mechanism of genetic drift.....	514
Box 11.8	Historical and ecological factors influencing the strength of social glue.....	516
Box 12.1	The shopping list.....	546
Box 12.2	Social mechanisms.....	548
Box 12.3	Dependent trajectories in city development.....	550
Box 12.4	Informal settlements in a border city.....	552
Box 12.5	The discovery of hypothesis and abduction.....	554
Box 12.6	The 'generality' of economics.....	556
Box 12.7	Equations versus agents: a prey-predator system.....	557

Box 13.1	Sugarscape in <i>NetLogo</i>	596
Box 13.2	Sex and demographic cycles	598
Box 13.3	The relevance of information in Kerala's fish markets.....	599
Box 13.4	Perceived probability and prospect theory	601
Box 14.1	The problem of the basted buttons	638
Box 14.2	The giant component.....	639
Box 14.3	The harmonious glow of fireflies.....	641
Box 14.4	The Mexican wave.....	643
Box 14.5	Milgram's experiment	644
Box 14.6	Simulation of a small world in an egalitarian network.....	646
Box 14.7	The Oracle of Bacon	647
Box 14.8	The breadth-first search method	648
Box 14.9	Kleinberg's search algorithm	650
Box 15.1	The power law and the scale-free property	680
Box 15.2	Popularity of network nodes and the power law	682
Box 15.3	Preferential attachment networks	684
Box 15.4	The adaptation function in the Bianconi-Barabási model and other accounts.....	686
Box 15.5	Temporary projects and networks of collaborators	688
Box 16.1	Examples of the social contagion of emotions.....	731
Box 16.2	Viral propagation through a network.....	732
Box 16.3	A model of social revolt.....	734
Box 16.4	Social conformity and Asch's experiment	736
Box 16.5	The effect of bounded confidence on networks with different topologies.....	738
Box 16.6	Percolation by sites in a bidimensional lattice.....	740
Box 16.7	Oil spills and soil pollution.....	741
Box 16.8	Dynamics of forest fires	743
Box 17.1	The 'El Farol' problem and experiential learning.....	777
Box 17.2	A computational model of the Minority Game	779
Box 17.3	Reinforcement learning	781
Box 17.4	Sustaining cooperation in a spatial learning game	783
Box 17.5	Belief-based learning with a best response criterion	785
Box 17.6	Conventions and learning processes.....	787
Box 17.7	Cognitive heterogeneity and its hierarchy	789

Box 18.1	Biological evolution as a metaphor.....	825
Box 18.2	A computational model of fitness landscapes.....	826
Box 18.3	Solving the problem of 'pure ones' with a GA.....	829
Box 18.4	<i>Robby</i> the can collector in <i>NetLogo</i>	831
Box 19.1	The Kolmogorov-Smirnov test.....	882
Box 19.2	Analytical sociology and social mechanisms	884
Box 19.3	Models of social interaction	885
Box 19.4	Calibration of the context and the individuals' decisions in an ABM.....	887
Box 19.5	The problem of over-fitting in the neoclassical approach	889
Box 19.6	The QWERTY keyboard and inertia	891
Box 19.7	Estimating the power law	892
Box 19.8	Detecting the power law	894
Box 19.9	Simulation of random numbers	896
Box 20.1	The Lucas critique and microfoundations.....	945
Box 20.2	Non-parametric test of stationarity and ergodicity	946
Box 20.3	Indirect calibration of parameters in <i>NetLogo</i> using genetic algorithms	950
Box 20.4	The emergence of ethnocentrism in an ABM	952
Box 21.1	Model of political competition with adaptive behaviours.....	1001