

# Contents

Preface	vii
1. Introduction to Collective Systems	1
1.1 Collective Outcomes of Interacting Agents .....	1
1.2 The Study of Collective Systems .....	5
1.3 The Price of Anarchy in Collective Systems .....	10
1.3.1 Collection action with strategic compatibility.....	11
1.3.2 Collection action with strategic complementarity..	14
1.4 Review of the Literature .....	17
1.5 Evolutionary Design of Desired Collective Systems .....	25
1.6 Outline of the Book.....	28
2. Introduction to Game Theory and Evolutionary Games	31
2.1 Classification of Games and Nash Equilibrium .....	31
2.2 Correlated Equilibrium .....	40
2.3 Interaction Structures .....	43
2.4 Learning in Games .....	47
2.5 Evolutionary Games.....	51
2.6 Relation between Learning and Evolution.....	57
2.7 Design of Learning and Evolving Agents.....	60
3. Social Interactions and Social Games	65
3.1 Social Interactions with Externalities.....	65
3.2 Binary Decisions with Externalities.....	67
3.3 Decomposition to Pair-wise Interactions .....	76
3.4 Compound Social Games.....	78

3.5	Nash Equilibrium and Collective Efficiency .....	86
3.6	Conflict Resolution between Collective Efficiency and Equity .....	95
4.	Micro-Macro Dynamics .....	101
4.1	A Threshold Model for Dealing with Heterogeneity in Agents .....	101
4.2	A Micro-Macro Loop .....	103
4.3	Two Facets of an Individual's Decision: Purposive and Contingent Decisions .....	107
4.4	Micro-Macro Dynamics within a Collective .....	112
4.5	Micro-Macro Loop between Two Collectives .....	119
4.6	Micro-Macro Dynamics between Two Collectives .....	122
5.	Knowledge Transaction Games .....	131
5.1	Merit of Knowledge Sharing .....	131
5.2	A Formulation of Knowledge Transaction Games .....	134
5.3	Characteristics of Knowledge Transaction .....	138
5.4	Repeated Knowledge Transaction .....	142
5.5	Knowledge Transaction by Multiple Agents .....	148
5.6	The Knowledge Accumulation Process as a Micro-Macro Loop .....	152
6.	Gains from Diversity .....	161
6.1	Identity and Diversity .....	161
6.2	Integration and Segregation .....	165
6.3	Global and Local Adaptation Models .....	167
6.4	Threshold Distributions and Locating Heterogeneous Agents .....	171
6.5	Performance Measures .....	176
6.6	Evaluation of Collective Adaptive Dynamics .....	181
7.	Selective Interaction and Reinforcement of Preference .....	191
7.1	Selective Interaction in Games .....	191
7.2	Evolution of Preference .....	194
7.3	Social Games with Neighbor Selection .....	197

7.4	Preference Reinforcement through Selective Interaction...	204
7.5	Coexistence of Conformists and Nonconformists.....	209
7.6	Development of Preference through Interaction .....	213
8.	Give-and-Take in Social Interaction	219
8.1	Social Interaction with the Logic of the Minority.....	219
8.2	Formalisms of Dispersion Games .....	224
8.3	The Price of Anarchy of Uncoordinated Collective Decisions.....	228
8.4	Learning Models in Dispersion Games.....	233
8.5	The Principle of Give-and-Take in Dispersion Games .....	236
8.6	Localized Dispersion Games and Emergence of Dynamic Orders in Harmony.....	240
8.7	Interpretation of the Principle of Give-and-Take.....	246
9.	Collective Evolution of Behavioral Rules	249
9.1	Repeated Interactions on Social Networks .....	249
9.2	Repeated Interactions with Bounded Memory.....	255
9.3	A Strategy Choice with a Coupling Rule.....	257
9.4	Iterated Prisoner's Dilemma Games on Social Networks..	264
9.5	Iterated Coordination Games on Social Networks.....	274
9.6	Iterated Hawk-Dove Games on Social Networks .....	278
9.7	Sustainable Coupling Rules .....	282
10.	Collective Evolution of Synchronized Behavioral Rules	287
10.1	Dispersion Games on Social Networks.....	287
10.2	Generalized Rock-Scissors-Paper Games .....	303
10.3	A Coupling Rule with a Memory of Two .....	306
10.4	A Coupling Rule with a Memory of Four.....	319
10.5	Effects of Implementation Error in Collective Evolution ..	324
10.6	From Co-evolution to Collective Evolution.....	332
	Bibliography	341
	Index	353