# Contents

Preface xi

PART I ▪ BACKGROUND AND FUNDAMENTALS OF NETWORK ANALYSIS

Chapter 1 Introduction 3
1.1 Why Model Networks? 3
1.2 A Set of Examples 4
1.3 Exercises 17

Chapter 2 Representing and Measuring Networks 20
2.1 Representing Networks 20
2.2 Some Summary Statistics and Characteristics of Networks 30
2.3 Appendix: Basic Graph Theory 43
2.4 Appendix: Eigenvectors and Eigenvalues 49
2.5 Exercises 51

Chapter 3 Empirical Background on Social and Economic Networks 54
3.1 The Prevalence of Social Networks 55
3.2 Observations on the Structure of Networks 56

PART II ▪ MODELS OF NETWORK FORMATION

Chapter 4 Random-Graph Models of Networks 77
4.1 Static Random-Graph Models of Random Networks 78
4.2 Properties of Random Networks 86
4.3 An Application: Contagion and Diffusion 105
4.4 Distribution of Component Sizes 107
4.5 Appendix: Useful Facts, Tools, and Theorems 110
4.6 Exercises 121

Chapter 5 Growing Random Networks 124
5.1 Uniform Randomness: An Exponential Degree Distribution 125
5.2 Preferential Attachment 130
5.3 Hybrid Models 134
5.4 Small Worlds, Clustering, and Assortativity 141
5.5 Exercises 150

Chapter 6 Strategic Network Formation 153
6.1 Pairwise Stability 154
6.2 Efficient Networks 157
6.3 Distance-Based Utility 159
6.4 A Coauthor Model and Negative Externalities 166
6.5 Small Worlds in an Islands-Connections Model 170
6.6 A General Tension between Stability and Efficiency 173
6.7 Exercises 179

PART III ▪ IMPLICATIONS OF NETWORK STRUCTURE

Chapter 7 Diffusion through Networks 185
7.1 Background: The Bass Model 187
7.2 Spread of Information and Disease 189
7.3 Search and Navigation on Networks 209
7.4 Exercises 221

Chapter 8 Learning and Networks 223
8.1 Early Theory and Opinion Leaders 224
8.2 Bayesian and Observational Learning 225
8.3 Imitation and Social Influence Models: The DeGroot Model 228
8.4 Exercises 253

Chapter 9 Decisions, Behavior, and Games on Networks 257
9.1 Decisions and Social Interaction 258
9.2 Graphical Games 269
9.3 Semi-Anonymous Graphical Games 273
9.4 Randomly Chosen Neighbors and Network Games 279
9.5 Richer Action Spaces 286
9.6 Dynamic Behavior and Contagion 293
9.7 Multiple Equilibria and Diffusion in Network Games 297
9.8 Computing Equilibria 304
9.9 Appendix: A Primer on Noncooperative Game Theory 308
9.10 Exercises 319

Chapter 10 Networked Markets 327
10.1 Social Embeddedness of Markets and Exchange 328
10.2 Networks in Labor Markets 334
10.3 Models of Networked Markets 353
10.4 Concluding Remarks 365
10.5 Exercises 366

PART IV ▪ METHODS, TOOLS, AND EMPIRICAL ANALYSES

Chapter 11 Game-Theoretic Modeling of Network Formation 371
11.1 Defining Stability and Equilibrium 372
11.2 The Existence of Stable Networks 377
11.3 Directed Networks 383
11.4 Stochastic Strategic Models of Network Formation 388
11.5 Farsighted Network Formation 395
11.6 Transfers and Network Formation 399
11.7 Weighted Network Formation 402
11.8 Agent-Based Modeling 406
11.9 Exercises 407

Chapter 12 Allocation Rules, Networks, and Cooperative Games 411
12.1 Cooperative Game Theory 412
12.2 Communication Games 416
12.3 Networks and Allocation Rules 419
12.4 Allocation Rules When Networks Are Formed 425
12.5 Concluding Remarks 430
12.6 Exercises 430

Chapter 13 Observing and Measuring Social Interaction 434
13.1 Specification and Identification 435
13.2 Community Structures, Block Models, and Latent Spaces 443
13.3 Exercises 457

Afterword 459

Bibliography 461

Index 491