
Contents

Introduction	xi
Part 1. Modeling the Relationships between Societies and Nature	1
Chapter 1. The Theoretical Context of Classical Geography	3
1.1. Environmentalism – a theory that is still rejected.	4
1.2. The theoretical double paradox of classical geography.	6
1.2.1. Majority refusal of the theoretical approach	6
1.2.2. Theories in physical geography viewed by sub-disciplines	6
1.2.3. Two paradigms borrowed from social sciences: structuralism and Marxism	7
1.2.4. Evolutionary theories at the core of classical geography	9
1.3. The general theory of systems and the theories derived therefrom	11
1.3.1. A formal theory to unite geography	11
1.3.2. Theories stemming from the general theory of systems	12
1.4. Conclusion	15
1.5. Appendix 2: Importing data within Mathematica.	15
Chapter 2. Statistical and Probability Models for Given Relationships Between Societies and the Natural Environment	19
2.1. Acknowledging the probability model for recorded data.	20
2.1.1. Four approaches to determine the probability law for a given series of data.	20
2.1.2. Case study: GNP/inhabitant in Africa.	22
2.2. Modeling the relationships between two or several variables	24
2.2.1. Responding to issues raised by a data table.	24
2.2.2. Avoiding the pitfalls of linear and monotonic correlation.	25

2.2.3. Regression models for all data types	20
2.2.4. Interpolation to bridge the missing data gap	30
2.2.5. Moving from classification to regionalization	30
2.2.6. Factorial analyses to jointly analyze both the structure of variables and the structure of geographic objects	40
2.3. Temporalities and time series models	40
2.3.1. The geographer faced with seven lines of questioning	40
2.3.2. Understanding and testing the non-stationarity of given evolution	40
2.3.3. Determining persistence: the correlogram and the variogram	50
2.3.4. Breaking down a series into trends, cycles and random behavior.	50
2.3.5. Pinpointing exceptional events, their intensity and their repetition	50
2.3.6. The difficult choice of a probability model.	60
2.3.7. Modeling bivariate and multivariate time series	60
2.4. Conclusion	70
2.5. Appendix 3: chronological program processing.	70
Chapter 3. Models of Ordinary Dynamic Systems	70
3.1. Four lines of questioning to understand the behavior of a dynamic system	70
3.2. Initiation in the modeling of dynamic systems	70
3.2.1. The stages of modeling through a system of ODEs	70
3.2.2. Discrete time and continuous time: difference equations and differential equations	70
3.2.3. Three methods, which are analytical, numerical and qualitative as a means to study a dynamic system	70
3.2.4. The qualitative approach of dynamic systems	80
3.3. Assets and restrictions of ODE models	90
3.3.1. The contributions to differential equation models in understanding the evolution of geographical systems.	90
3.3.2. A constraint overcome: the reductionism of these models	90
3.4. More realistic models of geographical systems	90
3.4.1. Exploitation of stock: fisheries, non-renewable resources and sustainable development	90
3.4.2. Time delays and introducing exceptional events into a dynamic model	90

3.4.3. Patterns of interaction between two populations	98
3.4.4. Multi-stock system behavioral models	103
3.5. Conclusion	109
3.6. Appendix 4: crowd behavior in catastrophic situations.	109
Part 2. Modeling Geographic Locations	113
Chapter 4. Theories of Geographical Locations	115
4.1. Introduction to spatial economic theories	116
4.1.1. Von Thünen's theory: the location of agricultural produce	116
4.1.2. Weber's theory of industrial location	118
4.1.3. Two categories of theories to explain service activity location	120
4.2. A new urban economy and a new economic geography	123
4.2.1. New locations in contemporary space.	123
4.2.2. Alonso: von Thünen's theory applied to the city.	124
4.2.3. Issues with the new economic geography.	126
4.2.4. Works behind numerous theoretical models	127
4.3. Conclusion	128
Chapter 5. Theoretical Geolocation Models	129
5.1. Von Thünen and d'Alonso's monocentric and polycentric models	130
5.2. Steiner's model generalizes Weber's.	132
5.3. Central place models in the making	134
5.4. Conclusion	135
Part 3. Spatial Structures and Territorial Dynamics	137
Chapter 6. Theories Used to Understand Territorial Structures and Dynamics	139
6.1. From terrestrial to geographical space	139
6.1.1. Space as a multidisciplinary concept	139
6.1.2. A reality: terrestrial space. A concept: geographical space	140
6.1.3. Territory: an ecological notion borrowed by geography.	141
6.2. Some theories drawn from various fields and used to explain simple territorial forms	141
6.2.1. Some linear-gradient spatial structures imposed by nature or produced by societies	142
6.2.2. Several theories used to explain concentrated territorial organizations	143
6.2.3. Three discontinuity theories, including a geographical one	145

6.3. From morphology to morphogenesis.	14
6.3.1. The basic mechanisms of morphogenesis: growth, movement, emergence and symmetry breaking	14
6.4. An overview of morphogenetic theories.	15
6.4.1. Schelling's theory and social interaction theories	15
6.4.2. The reaction-diffusion theory and its generalization	15
6.4.3. The theory of self-organized critical systems.	15
6.4.4. Bejan's constructal law and its ramifications.	15
6.4.5. Nottale's theory of scale relativity.	16
6.5. Conclusion	16
6.6. Appendix 5: globalization at the root of a paradox: homogenization and global fracturing	16
Chapter 7. Models of Basic Structures: Points and Fields	16
7.1. Modeling the point structures of a geographical space	16
7.1.1. Four categories of questions	16
7.1.2. Observing and summarizing a distribution of points: density, mean and median centers	16
7.1.3. Testing the random, regular or concentrated distribution of points.	16
7.1.4. Spatial dependence: autocorrelation and variography	16
7.1.5. Spatial interpolation: creating fields from data points	17
7.2. Modeling geographical fields.	17
7.2.1. Some contributions of related fields.	17
7.2.2. Global study of geographical fields	18
7.2.3. Local study of geographical fields.	19
7.3. Conclusion	19
7.4. Appendix 6: Introduction to the morphometric analysis of the Grenoble Alps	19
Chapter 8. Models of Basic Structures: Networks	19
8.1. The two aspects of a network: graphs and matrices.	19
8.1.1. From the graphic representation of a network...	19
8.1.2. ...To its matrix representations...	20
8.2. Modeling the structure of a spatial network	20
8.2.1. Centrality, hierarchy, power and prominence in a network	20
8.2.2. Cohesion and communities of a network	20
8.2.3. Three models of network structures.	21
8.3. Qualitative geographical models and graph theory	21
8.3.1. Modeling affiliation relationships	21
8.3.2. Elaborating conceptual models	21
8.3.3. Modeling online social networks	21

8.4. Modeling network dynamics	214
8.4.1. Optimization in fixed networks	214
8.4.2. Temporal evolution of networks.	219
8.4.3. Models of movements channeled by networks.	221
8.5. Conclusion	221
8.6. Appendix 7: A geometric approach to the network of French metropolises	222

Chapter 9. Geographical Space as a Mixture of Basic Spatial Structures

9.1. Testing links between two elementary spatial structures.	225
9.1.1. Finding correspondences between two elementary structures of the same type	226
9.1.2. Relationships between two different basic structures	230
9.2. Modeling complex spatial structures: machine learning and choremes	233
9.2.1. Two examples of complex spatial structures	233
9.2.2. A chorematic approach updated by machine learning.	234
9.3. Modeling multiscale spatial structures.	237
9.3.1. Wavelet decomposition models of a spatial structure	238
9.3.2. Models of information entropy decomposition for mesh data.	242
9.3.3. Multifractal models.	244
9.3.4. Comparing two multiscale spatial structures	247
9.4. Conclusion	248

Chapter 10. Morphogenetic Macro- and Micro-models

10.1. Time series typical of morphogenetic theories.	249
10.1.1. Testing the chaotic behavior of a time series	250
10.1.2. Testing the fractality of data to verify the theory of self-organized critical systems.	251
10.1.3. Log-periodic behaviors represent an indicator of the scale relativity theory	251
10.2. Modeling the dynamics of territorial systems: from ODEs to PDEs	252
10.2.1. The components of a spatialized dynamic system	252
10.2.2. Some instructive models	254
10.3. Cellular automata, Brownian motions and multi-agent systems	261
10.3.1. The definition of a “cellular automaton”	261
10.3.2. Brownian motions for the simulation of movements.	266
10.3.3. The contribution of multi-agent systems	270
10.3.4. A kind of universal modeling.	271

Bibliography	28
Index	29