Dimitrios S. Dendrinos Michael Sonis

Chaos and Socio-Spatial Dynamics

With 49 Illustrations



Springer Science+Business Media, LLC

Dimitrios S. Dendrinos Urban and Transportation Dynamics Laboratory 2011 Learned Hall University of Kansas Lawrence, KS 66045-2962 USA Michael Sonis Department of Geography Bar-Ilan University Ramat-Gan 52900 Israel

Editors F. John

Courant Institute of Mathematical Sciences New York University New York, NY 10012 USA J.E. Marsden
Department of
Mathematics
University of California
Berkeley, CA 94720
USA

L. Sirovich
Division of
Applied Mathematics
Brown University
Providence, RI 02912
USA

Mathematical Subject Classifications: 58F, 92A, 34G, 35F, 35G, 35K, 58E, 76F, 90A, 34C, 34D, 34K, 35B, 35E, 35J, 35R, 47H, 58C, 76E, 90B

Library of Congress Cataloging-in-Publication Data Dendrinos, Dimitrios S.

Chaos and socio-spatial dynamics/Dimitrios S. Dendrinos, Michael Sonis.

n cm

Includes bibliographical references (p.).

ISBN 978-1-4612-6974-8 ISBN 978-1-4612-0991-1 (eBook)

DOI 10.1007/978-1-4612-0991-1

1. Population geography—Mathematical models. I. Sonis, Michael. II. Title. HB 1951,D46 1990 90-9672

© 1990 by Springer Science+Business Media New York Originally published by Springer-Verlag New York in 1990 Softcover reprint of the hardcover 1st edition 1990

All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Springer Science+Business Media, LLC), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden.

The use of general descriptive names, trade names, trademarks, etc., in this publication, even if the former are not especially identified, is not to be taken as a sign that such names, as understood by the Trade Marks and Merchandise Marks Act, may accordingly be used freely by anyone.

Typeset by Asco Trade Typesetting Ltd., Hong Kong.

987654321

ISBN 978-1-4612-6974-8

Contents

Preface	vii
Acknowledgments	ix
List of Figures	XV
List of Tables	xvii
Prologue	1
Part I. Socio-Spatial Dynamics	4
A. Introduction	4
1. A Brief Look at the Literature	4
2. Some Simple Dynamic Models	9
3. The Location-Dependent Elements of a Theory of	
Socio-Spatial Dynamics	11
B. The Four Lenses to View Socio-Spatial Dynamics	11
1. The Absolute–Relative Lens	11
2. Continuous Dynamics	14
3. Discrete Dynamics: The Universal Discrete Relative Dynamics Model	19
Conclusions	23
Part II. One Stock, Two Regions	24
Summary	24
A. The First Iterate and Associated Analytical Properties of the Model:	
x(t+1) = 1/1 + AF[x(t)]	24
1. Overview	24
2. Fixed-Point Behavior and the Discrete Map	25
3. Competitive Exclusion Equilibria	31
4. Classification of Fundamental Relative Spatial Dynamics	32
B. Log-Linear Comparative Advantages Producing Functions:	
$F = x(t)^a [1 - x(t)]^b$	34
1. Interpretation and Discussion of the Log-Linear Model	34
2. Intervals of Stability of Equilibria	37
3. Analytical Properties of the Log-Linear Model	38
4. Geometric Description of the Iterative Process	43

Xii Contents

C. Higher Iterates and Fundamental Bifurcations in	
Discrete Dynamics	49
1. The Second Iterate and Two-Period Cycles	49
2. Analytical Description of Two-Period Cycles	54
3. Period-Doubling and the Feigenbaum Slope-Sequences	59
4. Domains of Nonexistence of k-Period Cycles $(k \ge 3)$ and	
the Hopf Equivalent Bifurcation	63
D. The Exponential Locational Advantages Producing Function	68
Conclusions	70
Part III. One Stock, Multiple Locations	72
Summary	72
A. The General Model	73
1. Analytical Results	73
2. Ranking of Stocks According to Size	75
3. Trajectory Domains for the One-Stock, Three-Location Model	77
B. The Log-Linear Comparative Advantages Model	80
1. Analytical Properties	80
2. Numerical Analysis for the One-Stock, Multiple-Location Model	83
C. Empirical Evidence	120
1. The Nine U.S. Regions and Their Aggregations	120
2. The Time Step and the Forces at Work	122
3. U.S. Regional Relative Population Instability	122
4. The Statistical Tests of Significance	125
D. Border Sequences in the One-Stock, Multiple-Location,	
Log-Linear Model	127
1. Some General Results	127
2. Areas of State Variable Movement in the One-Stock,	120
Three-Location, Log-Linear Model	128
E. One-Stock, Multiple-Location, Discrete-Time, Logistic Growth	130 130
Definition and Central Analytical Properties The Jacobi Matrix	130
3. Equilibria	131
Conclusions	132
Conclusions	132
Part IV. Multiple Stocks, Multiple Locations	135
Summary	135
A. The General Model	135
1. Analytical Results	135
2. The Log-Linear Specification	137
B. The Two-Stock, Two-Location Model	138
1. The General Case	138
2. The Log-Linear Specifications	140
3. An Example	141
4. Numerical Results for the Two-Stock, Two-Location,	
Log-Linear Model	142

Contents	xiii
C. The Two-Stock, <i>I</i> -Location Case	144
1. The General Specifications	144
2. The Log-Linear Specifications	149
D. The Two-Stock, Multiple-Location, Discrete-Time,	
Logistic Growth Model	151
1. Definitions and Analytical Properties	151
2. The Jacobi Block-Matrix	153
3. Dynamic Structure of the Equilibria	154
Conclusions	155
Epilogue	157
1. Six Central Issues	157
2. Three Areas of Application	162
3. Further Research Suggestions	168
Appendix I	
Second-Order Determinants of the Three-Location, One-Stock Model	171
Appendix II	
The Determinant of the Log-Linear Model	173
References	175
Author Index	179
Subject Index	181