

Contents

1. Introduction	1
2. Time and Change in Economics	7
2.1 Economic Evolution – An Introduction	7
2.2 Equilibrium Theories in Economic Analysis	8
2.3 Dynamic Theories in Economics	9
2.4 Samuelson’s Correspondence Principle and Its Limitations	11
2.5 Instabilities in Economic Analysis	13
3. Mathematical Aspects of Dynamic Systems	15
3.1 Dynamics and Equilibrium	15
3.2 Classifications of Two-Dimensional Differential Equations	20
3.3 The Principle of Linearized Stability	22
3.4 Lyapunov’s Direct Method	25
3.5 Structural Stability	27
3.6 Conservative Systems	30
3.7 Bifurcation Theory	34
3.8 Singularity Theory	40
3.9 Catastrophe Theory	43
Appendix: Remarks on Bifurcation Theory	46
4. Multiple Equilibria and Structural Changes in Economic Systems	48
4.1 Catastrophe Theory and Comparative Statics Analysis	48
4.2 Modeling Regional Dynamics	53
4.3 Some Examples of Structural Changes	55
4.3.1 Business Cycles in the Kaldor Model	56
4.3.2 Resource Management	57
4.3.3 Dynamic Transportation Modal Choice and Bifurcation	58
4.3.4 Multiple Equilibria in Wilson’s Retail Model	59
4.4 A Bifurcation Analysis for an Economic Growth Model	61
4.5 Singularity Theory in Economic Analysis	66
4.6 Remarks	67
5. Economic Cycles	68
5.1 Theories of Economic Cycles	68
5.2 Some Mathematical Results Related to Limit Cycles	72

5.2.1	The Poincaré-Bendixson Theorem and Its Applications to Economics	72
5.2.2	The Hopf Bifurcation Theorem	75
5.3	The Simplified Keynesian Business Cycle Model	78
5.4	Non-equilibrium in a Disequilibrium Model	81
5.5	Monetary Cycles in the Generalized Tobin Model	85
5.6	Oscillations in van der Ploeg's Hybrid Growth Model	90
5.7	Periodic Optimal Employment Policy	94
5.8	Optimal Economic Growth Associated with Endogenous Fluctuations	97
5.9	Remarks on Possible Further Bifurcations from Limit Cycles ..	100
5.10	Competitive Business Cycles in an Overlapping Generations Economy – A Discrete Model	102
6.	Economic Chaos in Deterministic Systems	106
6.1	Chaos in Deterministic Systems	106
6.2	Economic Chaos in a Discrete System	108
6.3	Aperiodic Optimal Economic Growth	114
6.4	Urban Dynamics – The Lorenz System	117
6.5	Chaos in an International Economic Model	121
6.6	Chaos and Economic Forecasting	122
6.7	Remarks	125
	Appendix: Some Criteria for Distinguishing Different Attractors	126
A.1	The Lyapunov Exponents for Differential Equations ...	126
A.2	The Lyapunov Exponents for Discrete Maps	128
A.3	The Signal, Power Spectrum, Autocorrelation Function and Poincaré Map	129
7.	Stochastic Processes and Economic Evolution	132
7.1	Random Processes and Economic Evolution	132
7.2	Stochastic Processes – An Introduction	134
7.2.1	Some Concepts in Probability Theory	135
7.2.2	Stochastic Processes	137
7.3	Birth-Death Processes and the Master Equation	140
7.4	A Non-equilibrium Model of the Schumpeter Clock	144
7.5	Effects of Noise on the Nonlinear Stochastic Systems Close to Critical Points	152
7.6	Effects of Random Environment on a Two-Dimensional Deterministic System Near Critical Points	156
7.7	Conclusions	159
8.	Urban Pattern Formation Process – Stability, Structural Changes and Chaos	161
8.1	Continuous Spatial Economics and Description of Urban Pattern Formation	161

8.2	The Implications of Structural Stability in the Two-Dimensional Economy	165
8.3	Economic Cycles in Puu's Spatial Multiplier- Accelerator Business Model	170
8.4	Spatial Diffusional Effects as a Stabilizer	174
8.5	Separation and Coexistence of Residents	177
8.6	Long-Term Traveling-Wave Urban Pattern	182
8.7	Instabilities and Urban Pattern Formation	185
	Appendix: Structural Changes in Two Pattern Formation Models	185
A.1	A Model for Morphogenesis	186
A.2	The Brusselator	188
9.	The Haken Slaving Principle and Time Scale in Economic Analysis	193
9.1	The Haken Slaving Principle	193
9.2	The Center Manifold Theorem	195
9.3	Singular Perturbations	198
9.4	Fast Variable Versus Slow Variable in Economic Analysis	202
9.5	The Time Scale in Economic Analysis	205
9.6	Another Problem – Understanding a Dynamic Man	208
	Appendix: The Slaving Principle for Stochastic Differential Equations	209
10.	Implications of Synergetic Economics	213
10.1	Synergetic Economics and Its Relations to Synergetics	213
10.2	Relations to Traditional Dynamic Economics	214
10.3	Competitive and Planned Economies and Synergetic Economics	218
10.4	Implications for Developed and Developing Economies	220
10.5	Chance and Necessity in Economic Life	222
10.6	Policy Decision in a Chaotic World	223
10.7	Relations Between Microeconomics and Macroeconomics	225
11.	Conclusions and Prospects for Further Research	228
	References	231
	Subject Index	239