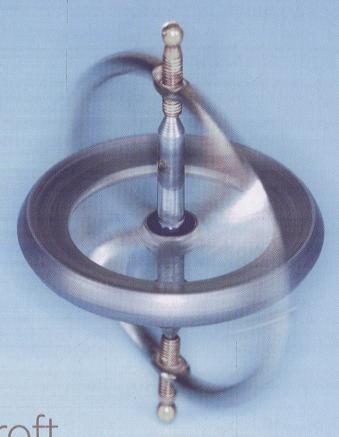
## Strategic Modelling and Business Dynamics

A feedback systems approach



John Morecroft

## **Contents**

About the Author		xviii
Foreword		xix
Preface and Acknowledgments  How to Use This Book		xxi xxxii
	Introduction	1
	A New Approach to Modelling	5
	The Puzzling Dynamics of International Fisheries	7
	Model of a Natural Fishery	10
	Simulated Dynamics of a Natural Fishery	12
	Operating a Simple Harvested Fishery	13
	Harvesting in Bonavista, Newfoundland - A Thought Experiment	15
	A Start on Analysing Dynamics and Performance Through Time Saving Bonavista - Using Simulation to Devise a Sustainable	18
	Fishery	20
	Dynamic Complexity and Performance Through Time	21
	Cunning Fish - A Scenario with Reduced Dynamic Complexity	23
	Preview of the Book and Topics Covered	25
	Appendix - Archive Materials from World Dynamics References	27 28
Chapter 2	Introduction to Feedback Systems Thinking	31
-	Ways of Interpreting Situations in Business and Society	31
	Event-oriented Thinking	32
	Feedback Systems Thinking - An Illustration	34
	A Shift of Mind	37
	The Invisibility of Feedback	38
	A Start on Causal Loop Diagrams	39
	Structure and Behaviour Through Time - Feedback Loops and the	
	Dynamics of a Slow-to-Respond Shower	41
	Processes in a Shower 'System'	43
	Simulation of a Shower and the Dynamics of Balancing Loops	45
	From Events to Dynamics and Feedback – Drug-related Crime  A Feedback View	46 48
	Scope and Boundary of Factors in Drug-related Crime	49
	An Aside - More Practice with Link Polarity and Loop Types	50
	Purpose of Causal Loop Diagrams - A Summary	51
	Feedback Structure and Dynamics of a Technology-based Growth	
	Business	51
	Causal Loop Diagrams - Basic Tips	5 <del>4</del>
	Picking and Naming Variables	54

	Meaning of Arrows and Link Polarity	<i>55</i>
	Drawing, Identifying and Naming Feedback Loops	56
	References	<b>5</b> 7
Chapter 3	Modelling Dynamic Systems	59
·	Asset Stock Accumulation	59
	Accumulating a 'Stock' of Faculty at Greenfield University	61
	Asset Stocks in a Real Organisation - BBC World Service	64
	The Coordinating Network	66
	Modelling Symbols in Use: A Closer Look at Drug-related Crime	67
	Equation Formulations	71
	Drug-related Crime	71
	Funds Required to Satisfy Addiction	73
	Street Price and Price Change	73
	Allocation of Police	75
	Experiments with the Model of Drug-related Crime	76
	A Tour of the Model	76
	Escalating Crime - The Base Case	78
	Drilling Down to the Equations	80
	Anomalous Behaviour Over Time and Model Boundary	81
	Benefits of Model Building and Simulation	85
	References	85
Chapter 4	World of Showers	87
	Getting Started	87
	Taking a Shower in World of Showers A	88
	Taking a Shower in World of Showers B	91
	Redesigning Your World of Showers	92
	Reflections on the World of Showers	94
	Metaphorical Shower Worlds in GlaxoSmithKline, IBM and	
	Harley-Davidson	95
	Inside World of Showers	98
	A Tour of Formulations in the Comfort-seeking Loop of the	
	Hidden Shower	98
	Interdependence of Showers - Coupling Formulations	101
	Simulations of World of Showers B	101
	References	103
Chapter 5	Cyclical Dynamics and the Process of Model Building	105
	An Overview of the Modelling Process	105
	Dynamic Hypothesis and Fundamental Modes of Dynamic	
	Behaviour	107
	Team Model Building	108
	Employment and Production Instability - Puzzling Performance	
	Over Time	111
	Dialogue About Production Control	114
	Thought Experiment: a Surprise Demand Increase in an Ideal	
	Factory	117
	Equation Formulations and Computations in Production Control Forecasting Shipments - Standard Formulations for	119
	Information Smoothing	120

	Inventory Control - Standard Formulations for Asset Stock	
	Adjustment	122
	Desired Production	123
	The Computations Behind Simulation	124
	Modelling Workforce Management and Factory Production Dynamics	128
	Dialogue About Workforce Management	128
	Operating Constraint Linking Workforce to Production	129
	Simulation of the Complete Model: A Surprise Demand Increase	
	in a Factory Where Production is Constrained by the Size of	
	the Workforce	130
	Pause for Reflection	134
	Equation Formulations in Workforce Management	135
	Departure Rate - Standard Formulation for Stock Depletion	135
	Hiring - Standard Formulations for Asset Stock Replacement	
	and Adjustment	136
	Workforce Planning	138
	Chronic Cyclicality in Employment and Production and How to	
	Cure It	139
	The Curious Effect of Random Variations in Demand	139
	Industry Cyclicality and Business Cycles	140
	Policy Formulation and What-ifs to Improve Factory Performance	143
	Modelling for Learning and Soft Systems	146
	A Second Pause for Reflection: System Dynamics and Soft	
	Systems	146
	A Link to Soft Systems Methodology	<i>151</i>
	Alternative Views of a Radio Broadcaster	153
	Appendix 1: Model Communication and Policy Structure Diagrams	155
	Appendix 2: The Dynamics of Information Smoothing	157
	References	160
Chapter 6	The Dynamics of Growth from Diffusion	163
Onapter o	Stocks and Flows in New Product Adoption - A Conceptual	.00
	Diffusion Model	164
	The Bass Model - An Elegant Special Case of a Diffusion Model	166
	The Dynamics of Product Adoption by Word-of-mouth	169
	The Need to Kick-start Adoption	170
	The Complete Bass Diffusion Model With Advertising	171
	The Dynamics of Product Adoption by Word-of-mouth and	2 / 2
	Advertising	173
	A Variation on the Diffusion Model: The Rise of Low-cost Air Travel	1/5
	in Europe	174
	easyJet - A Bright Idea, But Will it Work?	175
	Visualising the Business: Winning Customers in a New Segment	176
	Visualising Retaliation and Rivalry	179
	Feedback Loops in the easyJet Model	181
	Strategy and Simulation of Growth Scenarios	182
	Using the Fliers Simulator to Create Your Own Scenarios	185
	Simulation, Predictions and Scenarios	187
	Conclusion	187
	Appendix: More About the Fliers Model	188
	Back to the Future - From easyJet to People Express	189
	References	191

Chapter 7	Managing Business Growth	193
•	A Conceptual Model of Market Growth and Capital Investment	195
	Background to the Case	195
	Adopting a Feedback View	196
	Formulation Guidelines for Portraying Feedback Structure	198
	Review of Operating Policies and Information Flows in the	
	Market Growth Model	201
	Customer Ordering	201
	Sales Force Expansion	202
	Budgeting	203
	Capital Investment	204
	Goal Formation	206
	An Information Feedback View of Management and Policy	207
	Information Available to Decision Makers and Bounded	209
	Rationality	212
	Nature of Decision Making and the Decision Process	
	Policy Structure and Formulations for Sales Growth	213
	Sales Force Hiring - Standard Stock Adjustment Formulation	215
	Sales Force Budgeting - Revenue Allocation and Information	215
	Smoothing	215
	Order Fulfilment - Standard Stock Depletion Formulation	216
	Customer Ordering	218
	Policy Structure and Formulations for Limits to Sales Growth	218
	Customer Response to Delivery Delay - Non-linear Graphical	210
	Converter	219
	Customers' Perception of Delivery Delay - Information	221
	Smoothing	221
	Order Fulfilment and Capacity Utilisation	221
	Policy Structure and Formulations for Capital Investment	223
	Assessment of Delivery Delay	223
	Goal Formation - Weighted Average of Adaptive and Static	221
	Goals	224
	Capacity Expansion - Fractional Asset Stock Adjustment	225
	Production Capacity - Two-Stage Stock Accumulation	227
	Simulation Experiments	228
	Simulation of Sales Growth Loop	229
	Strength of Reinforcing Loop	232
	Simulation of Sales Growth and Customer Response Loops Simulation of the Complete Model with all Three Loops Active –	233
	The Base Case	<i>237</i>
	Redesign of the Investment Policy	241
	Top Management Optimism in Capital Investment	242
	High and Unyielding Standards - A Fixed Operating Goal for Delivery Delay	244
	Policy Design, Growth and Dynamic Complexity	247
	Conclusion	248
	Overview of Policy Structure	248
	Growth and Underinvestment at People Express?	251
	More Examples of Growth Strategies that Failed or Faltered	253
	Appendix - Gain of a Reinforcing Loop	253
	References	255 255

Chapter 8	Industry Dynamics – Oil Price and the Global Oil Producers	257
	Problem Articulation - Puzzling Dynamics of Oil Price	258
	Towards a Dynamic Hypothesis	260
	Model Development Process	261
	A Closer Look at the Stakeholders and Their Investment Decision	
	Making	264
	Investment by the Independent Producers	265
	Development Costs	266
	Policy Structure and Formulations for Upstream Investment -	
	Fractional Asset Stock Adjustment	268
	Oil Price and Demand	270
	The Swing Producer	272
	Quota Setting	274
	The Opportunists	275
	Russian Oil - Incorporating the Unforeseen	277
	Connecting the Pieces - A Feedback Systems View	278
	Two Invisible Hands and More	279
	The Visible Hand of OPEC	281
	Webs of Intrigue - Inside OPEC's Opulent Bargaining Rooms	282
	A Simple Thought Experiment: Green Mindset and Global Recession	284
	Using the Model to Generate Scenarios	285
	Archive Scenario 1: 10-Year Supply Squeeze Followed by Supply	20)
	Glut	286
	Archive Scenario 2: Quota Busting in a Green World	291
	Contemporary Scenario: Asian Boom with Quota Busting,	
	Cautious Upstream Investment and Russian Oil	294
	A Contemporary High Price Scenario - How to Push Oil Price	
	Over \$60 per Barrel	299
	Devising New Scenarios	301
	Effect of Global Economy and Environment on Demand	302
	Cartel Quota Bias	302
	Opportunists' Capacity Bias	302
	Oil Price Bias	303
	Capex Optimism	303
	Time to Build Trust in Russia (only in Oil World 1995)	303
	The Oil Producers' Microworld	304
	References	306
Chapter 9	Public Sector Applications of Strategic Modelling	307
-	Urban Dynamics - Growth and Stagnation in Cities	308
	Urban Model Conceptualisation	309
	Policy Implications of Urban Dynamics	313
	Medical Workforce Dynamics and Patient Care	314
	Background	315
	Medical Workforce Planning Model	316
	Quality of Patient Care	320
	Base Run - Changing Composition of the Medical Workforce	322
	Base Run - Quality of Patient Care	323
	Intangible Effects of the European Working Time Directive	$\frac{325}{324}$
	Modelling Junior Doctor Morale	325
	Overview of the Complete Model	325 326
		020

	The Formulation of Work-life Balance and Flexibility	327
	Simulations of the Complete Model	329
	Conclusions from the Medical Workforce Study	331
	Fishery Dynamics and Regulatory Policy	335
	Fisheries Management	335
	A Simple Harvested Fishery - Balancing Catch and Fish	
	Regeneration	337
	A Harvested Fishery with Endogenous Investment - Coping with	
	a Tipping Point	340
	Simulated Dynamics of a Harvested Fishery with Endogenous	
	Investment	344
	Control and Regulation - Policy Design for Sustainable Fisheries	345
	Formulation of Deployment Policy	346
	Stock and Flow Equations for Ships at Sea, Ships in Harbour	2 (0
	and Scrap Rate	349
	Simulated Dynamics of a Regulated Fishery - the Base Case	349
	Policy Design - A Higher Benchmark for Fish Density	352
	Dynamics of a Weakly Regulated Fishery	<i>354</i>
	Policy Design - Lower Exit Barriers Through Quicker Scrapping	250
	of Idle Ships	356
	Sustainability, Regulation and Self-Restraint Conclusion	360
		360
	Appendix - Alternative Simulation Approaches	361
	From Urban Dynamics to SimCity  Discrete event Standation and System Dynamics	362
	Discrete-event Simulation and System Dynamics Conclusions on Alternative Approaches to Simulation Modelling	362 369
	References	371
	ACTO DIACO	3/1
Chapter 10	Model Validity, Mental Models and Learning	373
	Mental Models, Transitional Objects and Formal Models	374
	Models of Business and Social Systems	376
	Tests for Building Confidence in Models	377
	Model Confidence Building Tests in Action: A Case Study in	
	Fast-moving Consumer Goods	379
	Soap Market Overview	380
	The Modelling Project	381
	Model Structure Tests and the Soap Industry Model	381
	Boundary Adequacy and Structure Verification Tests Applied to	
	a Simple Soap Model	383
	A Refined View of the Market	<i>385</i>
	Boundary Adequacy and Sector Map of the Complete Soap Industry Model	387
	Managerial Decision-making Processes in the Old English Bar	54,
	Soap Company	388
	Managerial Decision-making Processes in Global Personal Care	390
	Managerial Decision-making Processes in Supermarkets	391
	Equation Formulation Tests and the Soap Industry Model	392
	Substitution of Bar Soap by Shower Gel	392
	Brand Switching Between Competing Bar Soap Products	393
	Model Behaviour Tests and Fit to Data	398
	Tests of Fit on Simulations of the Soap Industry Model - The	
	Base Case	401

Tests of Learning from Simulation	405
Comparing Simulations with Expectations and Interpreting	
Surprise Behaviour	406
Partial Model Tests to Examine Pet Theories and Misconceptions	406
Family Member Tests	408
Policy Implication Tests	408
Understanding Competitive Dynamics in Fast-moving	
Consumer Goods	409
Summary of Confidence Building Tests	410
Conclusion - Model Fidelity and Usefulness	413
References	417
	419

Index