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Jeffrey Yi-Lin Forrest

General Systems Theory

Foundation, Intuition and Applications in Business Decision Making

Springer

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Preface of the Current Edition

Since the first edition, entitled "General Systems Theory: A Mathematical Approach," was initially published in 1999, many magnificent and important developments have been made at various fronts of systems science. So, at this very special moment of inaugurating the new leadership for the IFSR International Series on Systems Science and Engineering, it is definitely a good time for me to update the previous edition by enriching it with some of the most important works published since the start of this new century.

Because of my background and training in mathematics and my strong curiosity on a wide range of topics, as soon as I had my hands on the idea of and work on systems science by some of the best minds of our modern time in the early 1980s, I immediately became and have ever since been a faithful follower of the systems movement. I have been firmly convinced that systems research will provide a new dimension to the existing spectrum of science. Such belief was later argued comprehensively and spelled out clearly by George Klir in the early 1990s. However, with nearly one hundred years of development, systems science still needs to enhance itself in many different aspects in order to fully meet the challenges posed by several scholars, including David Berlinski (in his book *On Systems Analysis*, MIT Press, Cambridge, Massachusetts, 1976). In particular, other than addressing a set of new problems that were not possible to be considered in the past within the scope of the traditional science, systems science has to be able to provide solutions to problems, be them age old or modern, considered in various disciplines of the traditional science with its unique intuition, logic of thinking, and technical approach. Only with such a scientific capability, systems science will be affectionately embraced by the entire world of learning.

That means, in other words, that systems science needs to develop its own intuition and playground, like the one in modern science, known as Cartesian coordinate system, on which most important conclusions and results, be them systems science specific or not, can be visually seen by all educated eyes. For example, in modern science basic methods of analytical reasoning are all established on the Cartesian coordinate system of various dimensions; all statistical tools are developed on the top of various combinations, again Cartesian coordinate system based, of algebra and geometry. With such a playground and tool for intuitive reasoning in place, systemic logic of thinking can be systematically developed so that particular technical methods of reasoning will be established accordingly. In other words, to realize the great promise of systems science, there is a need to make this new science possess a glorious and long-lasting life. That means this new science needs to satisfy the following four conditions (Lin, Y. (2009), Systemic Yoyo: Some Impacts of the Second Dimension, CRC Press, New York):

1. It must be readable by as many people as possible.
2. It must coincide with people's intuition.
3. It must possess a certain kind of beauty, which can be easily felt.
4. It must be capable of producing meaningful results and insights that excite the population.

In the traditional science, calculus satisfies these conditions with its beauty manifested and intuition played out on the Cartesian coordinate system. Euclidean geometry is also a long living theory, because it is intuitive, possesses a logical and visual beauty, and can be employed in people's daily lives. In comparison, systems science did not have its unique playground and intuition, before at least of the start of this new century, through which the beauty of the science can be easily felt, and on which meaningful results and insights can be established.

To improve the general systems theory, as presented in the first edition published in 1999, this volume will introduce the systemic yoyo model as the desired playground and intuition for systemic reasoning and thinking. Other than presenting the elementary properties of this model and how general systems would follow the laws on state of motion, we will look at the theoretical reasons why such a model for a general system would hold true, followed by several empirical supports.

To satisfy Condition 4 listed above, this book will consider several issues of business decision making and see how meaningful results and insights that excite the population can be produced by using the systemic yoyo model and related systems reasoning. In particular, we will closely look at the following topics:

1. Why sustainable competitive advantages are becoming transient, while markets change faster and customers are less patient than ever before?
2. How nonlinearity appears in demand/supply interactions;
3. When new market competitions appear;
4. Some mysteries of the family;
5. Why no fixed value system will ever be perfect;
6. How to potentially achieve management efficiency;
7. Why organizational inefficiency always exists;
8. How to deal with customers' indecisiveness through pricing strategies;
9. How to heighten the competitive spirits of sales' associates; etc.

The reason why I choose various scenarios of business decision making as the showcase of successful and exciting applications is because such words as "believe," "should," and "would" are widely used in the literature of economics and business. To me, what that reality means is that the theoretical reasoning that led to the conclusions in the first place is not reliable, and the author knows about it. On the contrary, these words are not generally used in natural sciences and mathematics. For example, scientists generally do not use these words when they speak of scientific facts. For instance, no one in science would speak as follows: When a cubic solid piece of iron is dropped in the water in a container, I *believe* that the metal block *would* sink to the bottom of the container. Instead, people simple state the fact as follows: The metal block *will* sink to the bottom of the container (without using the words *believe* and *would*)!!! What happens in the research of economics and business when compared to that of natural sciences and mathematics is that

1. When a rigorous tool of reasoning is used, the author does not know for sure whether or not he/she has considered all related factors.
2. A lot of conclusions are drawn based on one or a few anecdotes without any follow-up rigorous analysis.
3. A lot of so-called theories are really established on data mining.

One of the reasons for Situation 1 to occur is that there is no readily available playground or intuition for large-scale or global economic reasoning. So, when a rigorous or analytical tool is employed, it tends to only model a regional, local phenomenon so that conclusions of a larger scale can only be conjectured. When Situation 2 is the case, the conclusions are really derived inductively instead of deductively. To this end, there are many counterexamples in mathematics that show the fact that observations based on anecdotes generally do not lead to reliable theories. For example, from the anecdote $0^2 = 0$ can one conclude that $n^2 = n$, for any natural number n? Of course not. Situation 3 above is similar to the case that we look at the clouds in the sky and ask each other: Do you see a person in the clouds who is smiling at us right now? Even when all people agree with you on the observation, one still cannot conclude that there is indeed a person in the sky who is smiling at people on earth. As a matter of fact, whatever methods used in Situations 2 and 3 above are only employed to reveal *potential* facts. These *potential* facts still need to be shown scientifically. For details about this end, see Lin Y. and OuYang S. C. (2010), *Irregularities and Prediction of Major Disasters*, New York: CRC Press.

If we identify the current state of research affairs in economics and business with that in the history of natural sciences right around the time when Isaac Newton developed his laws of physics, one can see such a possibility of great likelihood to happen: All the facts and nonfacts discovered in the literature of economics and business are similar to those uncovered by various scholars in natural sciences a few hundred years ago, and the present opportunity created by the development of systems thinking and the systemic intuition in the last century is quite parallel to that used by Newton to develop his laws of physics, because of the matrimony of Euclidean geometry and algebra, as a natural consequence of the introduction of the Cartesian coordinate system. So, considering the massive amount of facts and nonfacts discovered currently, one can expect a major breakthrough in areas of economics and business is coming soon. And, because of the fact of how systems science and the yoyo model can provide effective means for large-scale analysis and intuitive thinking, I expect that when such a breakthrough appears, it will be systems science based.

Summarizing what is discussed above, this volume is a follow-up edition of my previous book, entitled "General Systems Theory: A Mathematical Approach," initially published in 1999. And more than two thirds of the contents in this current book are based on recent developments in the relevant areas of research. In particular, this new edition consists of three parts, entitled *The Foundation*, *The Systemic Intuition*, and *Applications in Business Decision Making*, respectively. Other than some slight changes and additions, the first part is on the foundation of general systems theory and is mainly based on the earlier edition. The second part introduces the systemic yoyo model to satisfy the desperate need for a practically useful intuition for reasoning in systems science specific contents, as mentioned previously. The role to be played by this model is expected to be similar to that played by the Cartesian coordinate system in the classical science, on top of which all statistical and analytical methods, widely and heavily employed in modern science, are developed. The third part looks at how systemic thinking and the yoyo model can be beautifully applied to address many important problems facing decision makers in business by organically combining methods of the classical science, the first dimension of the 2D spectrum of science, with those of systems science, the second dimension, as argued by George Klir in the 1990s. As of this writing, important decisions in business are mostly drawn based on data mining or anecdotes. Scientifically speaking, such processes of decision making have been time and again shown to be flawed. Because of this reason, this part of the book is expected to open up a brand new territory of research valuable for decision-making managers and working economics professionals.

By presenting a rigorously developed foundation, a tool for intuitive reasoning that is supported by both theory and empirical evidence, and extremely fruitful applications in economics and business, this book demonstrates the theoretical value and practical significance of systems science and its thinking logic. By making use of this science and by employing the systemic intuition, one can produce interesting, convincing, and scientifically sound results. As shown in this book, many of the conclusions drawn on the basis of systems science can be practically applied to produce tangible economic benefits.

To comprehend the following chapters in this book, here are the necessary mathematical knowledge. Since Part 1 of this book is mostly from the first edition, entitled "General Systems Theory: A Mathematical Approach," published by Kluwer Academic Publishers in 1999, as mentioned before in that edition, the mathematical background needed here is a beginner's basic understanding of the naïve and axiomatic set theories. On the other hand, if the reader likes to make contributions along the lines given in this part of the proposed book, then he/she will need a better comprehension of these set theories in order to derive insightful conclusions. To satisfy this in-depth need, the reader is advised to consult with the previous editor of this book, where more than sufficient depth of these set theories is provided in a single place. And for the rest of this book, calculus and some basic knowledge of game theory will be sufficient for the reader to understand what is presented.

By studying this book and by referencing back to it regularly, you, the reader, will master a brand new tool to resolve your problems and an intuition from which important insights can be acquired intuitively and useful decisions can be made relatively quickly without wasting unnecessarily your valuable time and a lot of the limited financial resources.

I hope you will enjoy reading and referencing this book in your scientific exploration, academic pursuit, and real-life practice. If you have any comments or suggestions, please let me hear from you by joining several thousands of other colleagues who have communicated with either me or other members of my research groups. I can be reached at jeffrey.forrest@sru.edu or jeffrey.forrest@yahoo.com.

Slippery Rock, USA Jeffrey Yi-Lin Forrest

Preface of the First Edition

As suggested by the title of this book, I will present a collection of coherently related applications and a theoretical development of a general systems theory. Hopefully, this book will invite all readers to sample an exciting and challenging (even fun!) piece of interdisciplinary research, that has characterized the scientific and technological achievements of the twentieth century. And, I hope that many of them will be motivated to do additional reading and to contribute to topics along the lines described in the following pages.

Since the applications in this volume range through many scientific disciplines, from sociology to atomic physics, from Einstein's relativity theory to Dirac's quantum mechanics, from optimization theory to unreasonable effectiveness of mathematics to foundations of mathematical modeling, from general systems theory to Schwartz's distributions, special care has been given to write each application in a language appropriate to that field. That is, mathematical symbols and abstractions are used at different levels so that readers in various fields will find it possible to read. Also, because of the wide range of applications, each chapter has been written so that, in general, there is no need to reference a different chapter in order to understand a specific application. At the same time, if a reader has the desire to go through the entire book without skipping any chapter, it is strongly suggested to refer back to Chapters 2 and 3 as often as possible.

The motivation to write this book came from the strong influence of historical works by L. von Bertalanffy, George Klir, and M. D. Mesarovic, and the book *On Systems Analysis,* by David Berlinski (MIT Press, Cambridge, Massachusetts, 1976). Berlinski's book and challenges from several scholars really made me decide to write such a book with strong applications in different scientific fields in order to justify the very meaning of existence for a general systems theory. At the same time, one of the important lessons we have learned from the several decade-old global systems movement, started and supported by many of the most powerful minds of our modern time, is that senseless transfer of statements (more specifically, theoretical conclusions or results) from one discipline to another makes people feel that general systems theory is a doubtful subject. To keep such unnecessary situations from occurring, we develop each application with rigorous logical reasoning. Whenever a bold conclusion is deduced, some relevant gaps in the reasoning process will be pointed out right on the spot or in the final chapter ("Some Unsolved Problems in General Systems Theory"). On the other hand, doubtful people will be as doubtful as they can no matter what facts or evidence are out there to show them their doubt is unfounded. For example, more than 100 years ago, when naive set theory was first introduced and studied, many first-class mathematicians did not treat it as a serious theory at all. Furthermore, Cantor, the founder, was personally attacked by these scholars. As a consequence, he was hospitalized and eventually died in a psychiatric hospital. Today, set theory has succeeded in a great many areas of modern science, including the entire spectrum of mathematics, when the central idea of infinity is employed in systems science, we can still hear doubters saying things like: Infinity? One can be sure that in an infinitely long period of time, a monkey will produce the great Beethoven's music! (A note: according to results in set theory, this statement is not true!)

The structure of my theoretical development in this book is the "top-down"—formalization—approach, launched in 1960 by Mesarovic. This approach is characterized by the following: (1) All concepts are introduced with minimal mathematical structures. (2) Additional mathematical conditions are added when necessary to display the richness of systems properties. At the same time, applicability is always used to test the mathematical conditions added.

Calculus is all that is needed to comprehend this book, since all other mathematical techniques are presented at appropriate levels.

Finally, I would to express my sincere appreciation to many individuals, too many to list. My thanks go to President Robert Aebersold and Vice President and Provost Charles Foust, Deans Charles Zuzak and Jay Harper of Slippery Rock University, Pennsylvania, whose academic support for the past several years was essential to finishing this book. I thank Dr. Ben Fitzpatrick, my Ph.D. supervisor, for his years' teaching and academic influence, Prof. Lotfi Zadeh, the father of fuzzy mathematics, for his keen encouragement, Prof. Xavier J. R. Avula, President of the International Association for Mathematical and Computer Modeling, for his personal influence and education on professional perfection for the past several years.

I hope you enjoy reading and referencing this book, and your comments and suggestions are welcome! Please let me hear from you—my e-mail address is jeffrey.forrest@sru.edu.

Jeffrey Yi-Lin Forrest

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Contents

1 Introduction 1
1.1 Historical Background 2
1.2 Whole Evolutions—Blown-Ups and Revolving Currents 6
1.3 Systems Philosophy and Methodology 9
1.4 The Reason for Looking at Applications in Economics and Business Areas 12
1.5 Organization of Contents in This Book 16
References 19

Part I The Foundation

2 The Concept of General Systems 25
2.1 Various Attempts 25
2.1.1 The Concept of Systems 26
2.1.2 The Set-Theoretical Definition of General Systems 30
2.1.3 Structures 31
2.1.4 L-Fuzzy Systems 32
2.1.5 G-Systems 33
2.2 Internalities of Systems 33
2.3 The Edifice of Systems 35
References 39

3 Mappings and Constructions of Systems 41
3.1 Mappings from Systems into Systems 41
3.2 Free Sums 45
3.3 Products and Cartesian Products 48
3.4 One-Level Products 51
References 54

4 Connectedness 57
4.1 Connected Systems 57
4.2 Connectedness of Constructed Systems 61
References 67

5 Hierarchies—Construction of Large-Scale Systems 69
5.1 Existence of Linkages 69
5.2 Mappings from Hierarchies into Hierarchies 74
5.3 Time Systems 77
References 80

6 Controllabilities 81
6.1 Controllabilities of Input–Output Systems 81
6.2 General Controllabilities 83
6.3 Controllability of Time Systems 89
References 91

7 Limit Systems 93
7.1 Existence of Limits 93
7.2 Induced Mappings Between Limits 97
7.3 Centralizability of Limits 100
References 101

8 Systems of Single Relations 103
8.1 Chaos 103
8.2 Attractors 106
References 110

9 The Feedback Mechanism 111
9.1 Linear Systems 111
9.2 Feedback Systems 114
References 119

10 Properties Invariant Under Feedback 121
10.1 Linearity 121
10.2 Mesarovic–Takahara Time Systems 123
10.3 Time-Invariable Realization 127
References 130

11 Decoupling of Single-Relation Systems 131
11.1 The Concept 131
11.2 Transferrable Properties 132
11.3 Decoupling Through Feedback 137
11.4 An Example 139
References 143

12 Decomposability Conditions 145
12.1 Global and Complex System Representations 145
12.2 Isomorphisms and Monomorphisms 149
12.3 Input–Output System Covering 152
12.4 Surjective Complex System Representation of Order n 156
References 162

Part II The Systemic Intuition

13 How Systems Could Be Intuitively Seen 165
13.1 The Systemic Yoyo Model 166
13.2 Properties of Systemic Yoyo Fields 172
13.3 Interactions of Systemic Fields 176
13.4 Laws on State of Motion 181
13.5 Remarks 187
13.5.1 How Calculus, a Pinnacle Achievement of Science, Was Made Possible? 187
13.5.2 Usefulness of Intuition 188
13.5.3 Validity of Figurative Analysis 189
References 191

14 Whole Evolutions, Where Systemic Yoyos Come from 193
14.1 Blown-Ups: Moments of Transition in Evolutions 193
14.2 Properties of Blown-Ups 195
14.2.1 Blown-Ups of Quadratic Models 196
14.2.2 Blown-Up Properties of nth Degree Polynomial Models, $n \geq 3$ 199
14.2.3 Blown-up of Nonlinear Time–Space Evolution Equations 202
14.3 Issues Facing Quantitative Infinity 203
14.3.1 An Implicit Transformation Between Euclidean Spaces and Curvature Spaces 204
14.3.2 Motions Represented by General Dynamic System 207
14.3.3 Wave Motions Versus Eddy Motions 209
14.4 Equal Quantitative Movements and Effects 212
14.5 Remarks 217
References 218

15 Some Empirical Justifications 221
15.1 Eddy Effects Caused by Changes in Density of Media of Movement 221
15.2 Conservation of Informational Infrastructure 226

15.2.1 Physical Essence of Dirac's Large Number Hypothesis . . . 227
15.2.2 The Angular Momentum Mystery of the Solar System . . . 230
15.2.3 Movements of the Atmosphere on Earth . . . 232
15.2.4 Conjecture of a Law of Conservation of Informational Infrastructure . . . 233
15.2.5 Impacts of the New Law of Conservation . . . 235
15.3 Bodily Communications that Can Be Felt Undoubtedly . . . 237
15.3.1 Visual Stares . . . 237
15.3.2 Reciprocal Impressions of People . . . 238
15.4 Remarks . . . 239
References . . . 240

Part III Applications in Business Decision Making

16 Economic Events and Processes . . . 243
16.1 How Market Demand and Supply Interact with Each Other . . . 244
16.2 Model Economic Cycles by Using Systemic Yoyos . . . 247
16.3 Emergence of Market Competitions . . . 249
16.4 Concluding Remarks . . . 254
References . . . 255

17 Issues of Competition . . . 257
17.1 Some Background Information . . . 258
17.2 The Market Conditions . . . 259
17.3 Coordinated Monopoly and Stagnation in Expected Profits . . . 264
17.4 Markets Change Faster and Customers Less Patient . . . 268
17.5 Once Sustainable Competitive Advantages Become Transient . . . 270
17.6 Conclusions . . . 274
References . . . 275

18 Some Issues of the Family . . . 277
18.1 How Could Selfish People Behave Unselfishly . . . 277
18.2 Two Mysterious Phenomena of the Family . . . 285
18.3 Why Is Any Established Value System Imperfect? . . . 290
18.4 Conclusions . . . 296
References . . . 297

19 Some Remarks on Organizational Efficiencies . . . 299
19.1 The Question that Is to Be Addressed . . . 300
19.2 Literature Review . . . 300
19.3 Individuals' Underlying Philosophical and Value Systems . . . 302
19.4 Forever Existence of Inefficiency . . . 306

19.5 One Possible Way to Achieve Managerial Efficiency 312
19.6 Principle of Organizational Inefficiency 313
19.7 Concluding Remarks 317
References 318

20 Dealing with Indecisive Customers Through Pricing 321
20.1 One Strategic Firm 322
20.2 All Firms Are Strategic 327
20.3 Which Price Strategy Leads to Higher Expected Profits? 331
20.4 Some Final Words 335
References 335

21 An Idea on How to Heighten the Competitive Spirits of Sales Associates 337
21.1 Sales Associates' Compensation 339
21.2 Associates' Sales at Cournot Equilibrium 341
21.3 Associates' Payoffs at Cournot Equilibrium 344
21.4 Private Cost Information and Expected Incomes 345
21.5 Associates' Incentive Weights 347
21.6 Remarks 348
References 349

22 Reducing the Adverse Effects of Speculative Capital 351
22.1 Categorizing Purchasing Power 352
22.2 Economic Sectors Defined Through Feedback Mechanism 354
22.3 The Main Result 358
22.4 A Strategy for National Defense 359
22.5 A Few Final Words 361
References 361

Index 363

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Dr. Jeffrey Yi-Lin Forrest also known as Yi Lin, holds all his educational degrees in pure mathematics and had one-year postdoctoral experience in statistics at Carnegie Mellon University. He had been a guest professor of economics, finance, and systems science at several major universities in China, including Nanjing University of Aeronautics and Astronautics. And currently, he is a professor of mathematics at Slippery Rock University, Pennsylvania, and the president of the International Institute for General Systems Studies, Inc., Pennsylvania. He serves either currently or in the past on the editorial boards of eleven professional journals, including *Kybernetes: The International Journal of Systems*, *Cybernetics and Management Science*, *Journal of Systems Science and Complexity*, *International Journal of General Systems*, etc. Some of his research was funded by United Nations, State of Pennsylvania, National Science Foundation of China, and German National Research Center for Information Architecture and Software Technology. As of the end of 2016, he has published well over 300 research papers and nearly 50 monographs and special topic volumes. Some of these monographs and volumes were published by such prestigious publishers as Springer, World Scientific, Kluwer Academic, Academic Press, etc. Over the years, his scientific achievements have been recognized by various professional organizations and academic publishers. In 2001, he was inducted into the Honorary Fellowship of the World Organization of

Systems and Cybernetics. His research interests are wide-ranging, covering areas like economics, finance, management, marketing, data analysis, predictions, mathematics, systems research and applications, philosophy of science, etc.

Synopsis

This book is a follow-up edition of my previous book, entitled "General Systems Theory: A Mathematical Approach," initially published in 1999. More than two thirds of the contents in this current volume are based on recent developments in the relevant area of research.

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By presenting a rigorously developed foundation, a tool for intuitive reasoning that is supported by both theory and empirical evidence, and extremely fruitful applications this book demonstrates the theoretical value and practical significance of systems science and its thinking logic. By making use of this science and by employing the systemic intuition, one can produce interesting, convincing, and scientifically sound results. As shown in this book, many of the conclusions drawn on the basis of systems science can be practically applied to produce tangible economic benefits.

By studying this book and by referencing back to it regularly, the reader, who would be either a graduate student, a researcher, or a practitioner in the areas of mathematics, either theoretical or applied, systems science or engineering, economics, and decision science, will master a brand new tool to resolve his/her problems and an intuition from which useful decisions can be made relatively quickly without wasting unnecessarily the valuable time and a lot of the limited financial resources.