IFSR International Series in Systems Science and Systems Engineering

Jeffrey Yi-Lin Forrest

General Systems Theory

Foundation, Intuition and Applications in Business Decision Making

Springer

IFSR International Series in Systems Science and Systems Engineering

Volume 32

Editor-in-chief

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ISSN 1574-0463
IFSR International Series in Systems Science and Systems Engineering
ISBN 978-3-030-04557-9   ISBN 978-3-030-04558-6 (eBook)
https://doi.org/10.1007/978-3-030-04558-6

Library of Congress Control Number: 2018961727

Mathematics Subject Classification (2010): 93

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

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

Acknowledgements

This book contains many research results previously published in various sources, and I am grateful to the copyright owners for permitting me to use the material. They include the International Association for Cybernetics (Namur, Belgium), Gordon and Breach Science Publishers (Yverdon, Switzerland, and New York), Hemisphere (New York), International Federation for Systems Research (Vienna, Austria), International Institute for General Systems Studies, Inc. (Slippery Rock, Pennsylvania), Kluwer Academic and Plenum Publishers (Dordrecht, The Netherlands, and New York), MCB University Press (Bradford, UK), Pergamon Journals, Ltd. (Oxford), Springer Nature, Taylor and Francis, Ltd., World Scientific Press, Wroclaw Technical University Press (Poland), and Emerald Publishing, UK.

I express my sincere appreciation to many individuals who have helped to shape my life, career, and profession. Because there are so many of these wonderful people from all over the world, I will just mention a few. Even though Dr. Ben Fitzpatrick, my Ph.D. degree supervisor, had left this material world, he will forever live in my works. His teaching and academic influence will continue to guide me for the rest of my professional life. My heartfelt thanks go to Shutang Wang, my M.S. degree supervisor. Because of him, I always feel obligated to push myself further and work harder to climb high up the mountain of knowledge and to swim far into the ocean of learning. To George Klir—from him I acquired my initial sense of academic inspiration and found the direction in my career. To Mihajlo D. Mesarovic and Yasuhiko Takaraha—from them I affirmed their chosen endeavor in my academic career. To Lotfi A. Zadeh—with personal encouragements and appraisal words from which I was further inspired to achieve high scholastically. To Shoucheng OuYang and colleagues in our research group, named Blown-Up Studies, based on our joint works, Yong Wu and I came up with the systemic yoyo model, which eventually led to the completion of the earlier book *Systemic Yoyos: Some Impacts of the Second Dimension* (published by CRC Press as an Auerbach book, an imprint of Taylor and Francis in 2008) and this book. To Zhenqiu Ren—with him I established the law of conservation of informational infrastructure. To Gary Becker, a Nobel laureate in economics, his rotten kid theorem has brought me deeply into economics, finance, and corporate governance, from which some of contents of this book are created jointly by Dillon Forrest and me.

Contents

About the Author

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.

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 mainly based on the original 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. The role to be played by this model is expected to be similar to that played by 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 two-dimensional 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 working managers and 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 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.

Chapter 1
Introduction

In our modern times, science develops quickly, technology renews itself in front of our very eyes, and management theories evolve in different directions. The most important and most obvious characteristic of the quickly developing science is that the forest of specialized and interdisciplinary disciplines can be easily seen, yet the boundaries of disciplines become blurred. In terms of the speedy renewing of technology, the most important and most obvious characteristic is that generations of newer gadgets with better functionalities appear with shortening time intervals, while unexpected products are designed and introduced into the marketplace in abundance. Regarding modern management techniques, an increasing number of new theories are developed with forever different insights provided.

That is, the overall trend of modern science is to synthesize all areas of knowledge into a few major blocks, as evidenced by the survey of an American national committee on scientific research in 1985 (Mathematical Sciences 1985), and that of modern technology is to make everything imaginable "smart" through using computer-related technologies and the knowledge of artificial intelligence. On the contrary, the theories of management seem to be more diverse than ever before without any sign of immediate convergence.

Because of the rapid progress of science, technology, and management theories, researchers and practitioners of scientific research and decision-making managers have been faced with unprecedented problems: How can they equip themselves with the newest knowledge? How can they handle the geometrically growing amount of new knowledge? And how can they cope with the faster-changing market environment and much less patient customers? If traditional methods of exploration and learning are employed without modification, then today's unpublished scientific results could become outdated tomorrow, and today's hot products could be out of fashion tomorrow. Facing these challenges, researchers, practitioners, and decision-making managers evidently need to acquire new skills and knowledge regarding how the concepts of wholes and parts and their relationships can be employed to investigate similar problems in different scenarios so that the points of view of interconnection and interdependence can be employed to observe the world in which we live.

J. Y.-L. Forrest, *General Systems Theory*, IFSR International Series in Systems Science and Systems Engineering 32, https://doi.org/10.1007/978-3-030-04558-6_1

In the second decade of the twentieth century, von Bertalanffy (1924) wrote:

> Since the fundamental character of living things is its organization, the customary investigation of the single parts and processes cannot provide a complete explanation of the vital phenomena. This investigation gives us no information about the coordination of parts and processes. Thus the chief task of biology must be to discover the laws of biological systems (at all levels of organization). We believe that the attempts to find a foundation for the theoretical point are a fundamental change in the world picture. This view, considered as a method of investigation, we call "organismic biology" and, as an attempt at an explanation, "the system theory of the organism."

(Note: Similarly, in the study of economics, Rostow (1960) wrote:

> The classical theory of production is formulated under essentially static assumptions which freeze – or permit only once-over change – in the variables most relevant to the process of economic growth. As modern economists have sought to merge classical production theory with Keynesian income analysis they have introduced the dynamic variables: population, technology, entrepreneurship, etc. But they have tended to do so in forms so rigid and general that their models cannot grip the essential phenomena of growth, as they appear to an economic historian. We require a dynamic theory of production which isolates not only the distribution of income between consumption, savings, and investment (and the balance of production between consumers and capital goods) but which focuses directly and in some detail on the composition of investment and on developments within particular sectors of the economy.)

From von Bertalanffy's statement, it can be seen that parallel to the challenge of modern science, technology, and management, formally proposed was a new concept of systems, which can be potentially used by researchers, practitioners, and decision-making managers to face their respective challenges. Tested in the past ninety some years, this concept of systems has been widely accepted by the entire spectrum of science and technology and by working economists and business professionals; for details, see Lin (1999) and Klir (1985).

This chapter consists of five sections. Section 1.1 analyzes the historical background for how systems science has appeared and why it has been widely accepted. Section 1.2 looks at how the evolution of systems should be seen holistically. Section 1.3 explains what systems philosophy and methodology entail. Section 1.4 addresses the reason why we closely look at applications in business areas in this book, and Section 1.5 presents how this book is organized.

1.1 Historical Background

Since the time when the concept of systems was formally introduced in the second decade of the twentieth century in biology (von Bertalanffy 1924), the concept has been widely applied either implicitly or explicitly in the entire spectrum of science, be it natural or social, and technology. Although it seems to be a quite recent phenomenon, as all new concepts studied in the world of learning, the ideas and thinking logic of systems have a long history. For example, Chinese traditional medicine, treating each human body as a whole, can be traced to the time of Yellow Emperor about

5,000 years ago, and Aristotle's statement that "the whole is greater than the sum of its parts" has been a fundamental problem in systems theory. In other words, throughout the history, mankind has been studying and exploring nature by using the thinking logic of systems. It is only in modern times that have some new contents been added to the ancient systems thinking. The methodology of studying systems as wholes adequately agrees with the development trend of modern exploration of nature and man itself, namely divide the object, event, and process of consideration into parts as small as possible while studying each and every of them carefully, seek interactions and connections between phenomena, and to observe and comprehend more and bigger pictures of nature than ever before.

In the recorded history, although the word "system" was never emphasized, we can still find many explanatory terms concerning the concept of systems. For example, Nicholas of Cusa, that profound thinker of the fifteenth century, linking medieval mysticism with the first beginning of modern science, introduced the notion of *coincidentia oppositorum*, the opposition or indeed fights among the parts within a whole which nevertheless forms a unity of higher order. Leibniz's hierarchy of monads looks quite like that of modern systems; his *mathesis universalis* presages an expanded mathematics which is not limited to quantitative or numerical expressions and is able to formulate much conceptual thought. Hegel and Marx emphasized the dialectic structure of thought and of the universe it produces: the deep insight that no proposition can exhaust reality but only approaches its coincidence of opposites by the dialectic process of thesis, antithesis, and synthesis. Gustav Fechner, known as the author of the psychophysical law, elaborated, in the way of the natural philosophers of the nineteenth century, supraindividual organizations of higher order than the usual objects of observation, for example, life communities and the entire earth, thus romantically anticipating the ecosystems of modern parlance. Here, only a few names are listed. For a more comprehensive study, see von Bertalanffy (1972).

Even though Aristotelian teleology was eliminated in the development of modern science, problems considered in it, such as the one that "the whole is greater than the sum of its parts," the order and goal directedness of living things, etc., are still among the problems of today's systems research. For example, what is a "whole"? What does "the sum of its parts" mean? Could the sum of parts sometimes be greater than the whole? Although decision-making managers and working professionals know the importance of these and other related problems, none of these problems has been actually studied and addressed in any of the classical branches of science. These classical branches of science have been established on Descartes' second principle and Galileo's method, where Descartes' second principle says to divide each problem of concern into as small parts as possible so that each part could possibly be investigated, and Galileo's method implies to simplify a complicated process into as basic portions and processes as possible so that each portion and process could potentially be comprehended; for details, see Kuhn (1962).

From this superficial discussion, it can be seen that the concept of systems we are studying today is not simply a product of yesterday. As a matter of fact, it is a reappearance of some ancient thought and a modern form of an ancient quest. This quest has been recognized in human struggle for survival with nature and has been studied at various points in time by using the languages of different historical moments.

Ackoff (1959) comments that during the past two decades, we witnessed the appearance of the key concept "systems" in scientific research; however, with the appearance of the concept, what changes have occurred in modern science? Under the name "systems research," many branches of modern science have shown the trend of synthetic development; research methods and results in various disciplines have been intertwined to influence the overall research progress, so one feels the tendency of synthetic development in scientific activities. This synthetic development requires the introduction of new concepts and new thoughts in the entire spectrum of science. In a certain sense, all of this can be considered as the center of the concept of "systems." Hahn (1967, p. 185), an ex-Soviet expert, describes the progress of modern science as follows: Refining specific methods of systems research is a widespread tendency in the exploration of modern scientific knowledge, just as science in the nineteenth century with forming natural theoretical systems and processes of science as its characteristics.

von Bertalanffy (1972) described the scientific revolution in the sixteenth–seventeenth centuries as follows: "(The Scientific Revolution) replaced the descriptive-metaphysical conception of the universe epitomized in Aristotle's doctrine by the mathematical—positivistic or Galilean conception. That is, the vision of the world as a teleological cosmos was replaced by the description of events in causal, mathematical laws." Based on this description, we can describe the change in today's science and technology as follows: At the same time of continuously using Descartes' second principle and Galileo's method, systems methodology is introduced to deal with problems of order and organization.

Should we continue to use Descartes' second principle and Galileo's method? The answer is yes for two reasons. First, they have been extremely effective in scientific research and administration, where all problems and phenomena could be decomposed into causal chains, which could be treated individually. That has been the foundation for all basic theoretical research and modern laboratory activities. In addition, they won victories for physics and led to several technological revolutions. Second, modern science and technology are not Utopian projects as described by Popper (1945), reknitting every corner for a new world, but based on the known knowledge, they are progressing in all directions with more depth, more applicability, and a higher level of difficulty.

On the other hand, instead of treating the world as a pile of infinitely many isolated objects, on which the concept of numbers is introduced with internal structures ignored and modern science is established, not every problem or phenomenon, especially when humans and social events are concerned with, can be simply described by causal relations. The fundamental characteristics of this world are its organizational structure and connections of interior and exterior relations of different matters. The study of either isolated parts or causalities of events and organizations can hardly explain completely or relatively globally our surrounding world. At this junction, the research progress of the three-body problem in mechanics, where the problem is about how three or more bodies would interact with each other, as compared to the two-body scenario as described in Newton's second law of motion, is an adequate example that shows why systems thinking is badly needed. So, as human race advances, studying problems with multi-causality or multi-relation will become more and more significant than ever before.

In the history of scientific development, the exploration of nature has always moved back and forth between specific matters or phenomena and generalities. Scientific theories need foundations and stimulations rooted deeply inside real-life practice, while being used to explain natural phenomena so that human understanding can be greatly enhanced and to provide guidelines for decision makers to take educated actions. In the following, we discuss the technological background for the development of systems science—that is, the need for such a science that emphasizes on order and organization which arose in the development of technology and from the requirement for increasingly higher levels of production and better efficiency of management.

There have had been many advances in technology in the modern history: energies produced by various devices, such as steam engines, motors, computers, and automatic controllers; self-controlled equipment from domestic temperature controllers to self-directed missiles; and the information highway and internet of knowledge and things, which have resulted in increased communication of new scientific results and practical successes. On the other hand, increasing speed of communication furthers scientific development to a different level and helps to intensify the market competition globally. Additionally, societal changes have brought forward more pressing demands for new construction materials and different management strategies. From these examples, it can be seen that the development of technology forces mankind to consider not only a single machine or matter or phenomenon, but also "systems" of machines and "systems" of matters and phenomena. The design of steam engines, automobiles, cordless equipment, etc., can all be handled by specially trained engineers. However, when dealing with the designs of missiles, aircraft, or new construction materials, for example, a collective effort, combining many different aspects of knowledge and know-how, has to be in place. Such joint, collective efforts include the combination of various techniques, machines, electronic technology, chemical reactions, people, etc. Here the relation between people and machines becomes more obvious, and uncountable financial, economic, social, and political problems are intertwined to form a giant, complicated system, consisting of men, machines, and many other components. It was the great political, technical, and personnel arrangement success of the American Apollo project—landing humans on the moon—that hinted about the fact that history has reached such a particular point that all aspects of science and technology have been developed maturely enough so that each rational combination of information or knowledge could result in unexpected consumable products and that different combinations of men and personalities could lead to various unforeseen outcomes.

A great many problems in production require locating the optimal point of the maximum economic effect and minimum cost in an extremely complicated network. This kind problem not only appears in industry, agriculture, military affairs, and business, but politicians are also using similar (systems) methods to seek answers to problems like air and water pollution, transportation blockages, decline of inner cities, and crimes committed by teenage gangs.

In manufacturing production, there exists a tendency that bigger or more accurate products with more profits are designed and produced. In fact, under different interpretations, all areas of learning have been faced with complexity, totality, and "systemality." This tendency betokens a sharp change in scientific thinking. By comparing Descartes' second principle and Galileo's method with systems methodology and considering the development tendency, as described previously, appearing in the world of learning and production, it is not hard to see that because of systems concepts, another new scientific and technological revolution will soon appear. To this end, for example, each application of systems theory points out the fact that the relevant classical theory needs to be further enriched somehow; see Klir (1970), Berlinski (1976); Lilienfeld (1978). However, not all scientific workers have this kind of optimistic opinion. Some scholars believe that it is an omen that systems science itself is facing a crisis; see Wood-Harper and Fitzgerald (1982) for details. Of course, who is right and who is wrong only time and history will have the ability to tell.

1.2 Whole Evolutions—Blown-Ups and Revolving Currents

When we enjoy the splendid fruits of modern science and technology, we still need to think about the limitations of and issues existing in the science and technology we inherited from the generations before us. From the primeval to modern civilizations, mankind has gone through a history of development for over several millions of years. However, a relatively well-recorded history goes back only as far as about 3,000 years. During this time frame, the development of science mirrors that of human civilizations. And, each progress of pursuing after the ultimate truth is that of getting rid of the stale and taking in the fresh and that of making new discoveries and new creativities. Each time when the authority was repudiated, science is reborn again. Each time when the "truth" was questioned, a scientific prosperity appears. That is, each time when people praise authorities, they are in fact praising ignorance.

At the turn of the twenty-first century, Shoucheng OuYang (Wu and Lin 2002) proposed the blown-up theory for purpose of addressing and resolving nonlinear evolution problems based on a reversed thinking logic, factual evidence, and over 30 years of reasoning and practice. It is found that in terms of the formalism, nonlinear evolution models represent the singularity problems of mathematical blown-ups of uneven formal evolutions; and in terms of physical objectivity, nonlinear evolution models describe mutual reactions of uneven internal structures of materials, organizations, and events. They no longer stand for a problem of formal quantities. Since uneven structures and organizations symbolize eddy sources, they lead to eddy motions, the mystery of nonlinearity, instead of waves. That mystery has been bothering mankind for over 300 years, is resolved at once both physically and mathematically by OuYang (Wu and Lin 2002). What is shown is that the essence of nonlinear evolutions is the destruction of the initial-value automorphic structures and the appearance of discontinuity. It provides a tool of theoretical analysis for studying objective transitional and reversal changes of materials, organizations, and events.

In the ancient scientific history of the Western civilizations, there existed two opposite schools on the structure of materials. One school believed that materials were made up of uncountable and invisible particles, named "atoms," the other school that all materials were continuous. A representative of the former school is the ancient Greek philosopher Democritus (about 460–370 BC) and the latter the ancient philosopher Aristotle (384–322 BC). Since abundant existence of solids made it easy for people to accept the Aristotelian continuity, the theory of "atoms" was not treated with any validity until the early part of the nineteenth century when J. Dalton (1766–1844) established relevant evidence. In principle, Leibniz and Newton's calculus were originated in the Aristotelian thoughts. Along with calculus, Newton constructed his laws of motion on the computational basis of calculus and accomplished the first successes in applications in celestial movements under unequal-quantitative effects. With over two hundred years of development, the classical theory of mechanics has gradually evolved into such a set of methods for analysis based on the concept of continuity that even nearly a century after quantum mechanics and relativity theory were established; the thinking logic and methods developed on continuity are still widely in use today.

Due to differences in environmental conditions and living circumstances, where the west was originated from castle-like environments and the east from big river cultures with agriculture and water conservation as the foundation of their national prosperities, the ancient eastern civilizations were different or even opposite of those of the west. So, naturally, Chinese people have been more observing about reversal and transitional changes of weathers and rivers. Since fluid motions are irregular and difficult to compute exactly, that was why the *Book of Changes* (Wilhalm and Baynes 1967) and *Lao Tzu* (time unknown) appeared in China. The most important characteristic of the *Book of Changes* is its way of knowing the world through images of materials and organizations with uneven internal structures and analyzing changes in events through figurative structures with an emphasis placed on irregularities, discontinuities, transitional, and reversal changes.

As pointed out by Wu and Lin (2002), in terms of symbolism, due to escapes in uneven forms from continuity, the evolution of any nonlinear evolution model is no longer a problem of simply extrapolating the given initial values or the past into the future. What is significant here is that through nonlinear evolutions, the concept of blown-ups can represent Lao Tzu's teaching that "all things are impregnated by two alternating tendencies, the tendency toward completion and the tendency toward initiation, which, acting together, complete each other," and agrees with non-initial-value automorphic evolutions as what the *Book of Changes* describes: "At extremes, changes are inevitable. As soon as a change occurs, things will stabilize and stability implies long lasting."

Since nonlinearity describes eddy motions (Lin 2007), there must exist different eddy vectorities and consequent irregularities. That is, the phenomenon of "orderlessness" is inevitable. When looking at fluid motions from the angle of eddies, one