Wei-Bin Zhang

The General Economic Theory

An Integrative Approach

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Preface

I seek a unity all-pervading.
Confucius

This book develops a general economic theory, not only integrating various ideas and theories from Adam Smith till Nobel Prize laureates in economics, but also establishing important relations among economic variables unrecognized in the literature of rigorous economic analysis.

I first met with modern economics about 37 years ago. I started to read economics in 1984 when I was sent by China's government to Japan in 1983 as a graduate student in civil engineering at Kyoto University. The library on campus was a dream world for the poor student. There were so many books and academic journals on different subjects freely and easily available. Best of all is that classical works and collected works of some great modern economists like Samuelson and Arrow were always on the shelves for me to pick up, read through, and digest. Samuelson accounted his choice of economics at exactly the right time: "To a person of analytical ability, perceptive enough to realise that mathematical equipment was a powerful sword in economics, the world of economics was his or her oyster in 1935. The terrain was strewn with beautiful theorems begging to be picked up and arranged in unified order." I feel luck to randomly study masters' original works in economics even without any idea to become an economist in Japan. It was an optimal choice for me to have spent the leisure time on economics as reading was the most economical and pleasant consumption among all the affordable activities.

Samuelson arranged the works of classical economists in a unified order with the principles of optimization and comparative statics analysis. Although he did not create a unified economic theory, he first applied many physical theories and concepts to modernize economics with the mathematical kit. When I came to know economics, Samuelson's works had already become classical and each piece of his important works had been mathematically refined and further developed. By the early 1990s after having read Samuelson's and his generation's works in formal economic theories, I began to ask whether it is possible to build a set of equations which unify the basic economic mechanisms of the existing economic theories within a *single* theoretical framework. In the *Foreword* to the Japanese translation

of my 1991 book *Synergetic Economics* (Zhang 1994), I outlined my aspiration to build a general economic theory in the following way:

> Indeed, it is only after laborious work in many fields of theoretical economics that I began to be conscious of the fact that it is time to build a logically compact theory which includes the main economic ideas of Smith, Malthus, von Thunen, Ricardo, Marx, Mills, Walras, Marshall, Schumpeter, and Keynes. It should also include, as special cases, the well-established mathematical models, such as the Arrow-Debreu general equilibrium model, the Tobin model, the Solow-Swan-Uzawa growth model, the Oniki-Uzawa trade model, the Kaldo-Pasinetti two-class model, the Ricardian Models by Morishima, Samuelson and Pasinetti, the Keynesian theory, and Alonso location model, to explain certain economic phenomena which cannot be explained by the traditional works. I have concentrated on this single task, since … the spring of 1989.

My *Synergetic Economics* published in 1991, completed in 1989, was perhaps the first comprehensive book on applying modern nonlinear theory and ideas from natural sciences to economics. It is a further development of Samuelson's *Foundation*. This book reports some of my progresses in the mission to build a general economic theory. In this book, by theories by Nobel Prize laureates in economics I refer to formal models proposed by some Nobel laureates in economics. The Nobel Prize is referred to The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel.

Over years I received many insightful and constructive comments on my works submitted to academic journals. I am thankful to the comments of many anonymous referees and the journal editors. I am very grateful to Editor Dr. Johannes Glaeser and Editorial Assistant Judith Kripp for effective cooperation. I would like to thank the anonymous referee for the valuable comments and suggestions. I thank for my wife, Gao Xiao, who brings me happiness and is always supportive for my research. I completed this book at the Ritsumeikan Asia Pacific University. I am thankful for and impressed by the timely and professional performances of the research office. The campus, facing the clean ocean illuminated by sun lights through unstable clouds, standing by the fogged-up valley, and relying on the beautiful mountains decorated by colors of leaves and flowers, tranquilizes me with songs of birds in the four seasons. I am grateful to the campus life sustained collectively by the colleagues, students, and staffs from over 100 countries.

Beppu, Japan Wei-Bin Zhang
Summer 2020

Reference

Zhang WB (1994) The foreword to the Japanese version of Synergetic Economics, translated by Asada T, Aruka Y, Inaba T, Hirosi W. The Chuo University Press, Tyoko

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Chapter 1
The Time for a Grand Economic Theory

The grand aim of all science is to cover the greatest number of empirical facts by logical deduction from the smallest number of hypotheses or axioms.
Albert Einstein

Mathematics is called the queen of all sciences. Advances in modern economics, especially after World War II, have been associated with applications of different fields of mathematics. The rapid development in nonlinear mathematics and computer in the last few decades has enabled economists to further explore, empirically and theoretically, the complexity of economic systems. The advance of nonlinear economics is a visionary revolution in economic thinking about change, time scale, and speed of changes which are conceptually essential not only for differentiating various schools of economic dynamics, but also for unifying ideas and theories in economics (and other fields in social sciences) within a single analytical framework. Before constructing the general economic theory, I outline a new paradigm of analytical economics in association with applications of nonlinear science and computer.

1.1 The *Synergetic Economics* Generalizes the *Foundations of Economic Analysis*

Funeral by funeral, theory advances.
Paul Samuelson

Economics, especially analytical economics, has experienced revolutionary changes in the last few decades. This revolution is caused by nonlinear science, which is composed of many branches, such as synergetics, theory of complexity, theory of self-organization, and chaos theory. The revolution implies that economics can analytically and effectively treat the economic reality as an organic whole, rather than collections of separate and unconnected parts as in traditional analytical economics.

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Having been influenced by different branches of nonlinear science, I started to apply nonlinear science to economics about 35 years ago. I call this theory synergetic economics (Zhang 1989 or 1991) as it is based on synergetics created by Haken (1977, 1983). Synergetics deals with collective static or dynamic phenomena in closed or open multi-component systems with cooperative interactions occurring between the units of the system. Synergetics concentrates on the structural self-organizing space–time features of systems on a macroscopic level. It turns out that on this level, there exist close analogies between various systems in physics, chemistry, and biology, though they are composed of different units with completely different elementary interactions. From this new scientific perspective, theories reveal on how order gives way to chaos, order is discovered within chaos, and order is again created out of chaos.

The basic tool in synergetics is nonlinear mathematics. The theory is initiated by Poincaré (1854–1912) who revolutionized the study of nonlinear differential equations by introducing the qualitative techniques of geometry and topology rather than strict analytic methods to discuss the global properties of solutions of these systems. The study of dynamic systems was furthered in the Soviet Union, by mathematicians such as Liapunov, Pontryagin, Andronov, and others. Around 1975, many scientists around the world were suddenly aware that there is a new kind of motion—now called chaos—in dynamic systems. The new motion is erratic, but not simply "quasiperiodic" with many periods. What is surprising is that chaos can occur even in a very simple system. With the recent fast development of computers, scientists have been able to see that complicated behavior of high-dimensional nonlinear dynamic systems.

Before modern nonlinear science was introduced to economics, analytical economics had been dominated by Samuelson's magnum opus *Foundation of Economic Analysis*. Paul Samuelson (1915–2009) made great contributions to development of formal economics. He was awarded the 1970 Nobel Prize in economics: "for the scientific work through which he has developed static and dynamic economic theory and actively contributed to raising the level of analysis in economic science." He had played a great role in bringing rigorous analysis to economics that had previously relied on mostly verbal and graphical analysis. His *Foundation* started a new epoch of economic analysis. The *Foundation* was based on his Harvard Ph.D. dissertation. He attempted to formalize economic problems as maximizing or minimizing subject to constraints. His other influential book *Economics: An Introductory Analysis*, first published in 1948, effectively provided the world a common analytical tool with which microeconomic and macroeconomic phenomena of various parts of the world can be understood, analyzed, interpreted, discussed, and taught. Since its publications, the *Economics* has globally framed textbooks on introduction to modern economics till today. It did not take me long time to generalize the *Foundation* as the generalization was carried out by applying nonlinear science to economics. It has taken me three decades to put many seemingly unconnected ideas and theories in economics into a single analytical framework.

In the *Foundations*, Samuelson broadly classified the development of analytical economics into five steps. First, in Walras one has the final culmination of concept

of equilibrium. Pareto and others took a second step which laid the basis of a theory of comparative statics. The third step, which is characterized by maximizing action within an economic unit, was mainly carried out by W. E. Johnson, Slutsky, Hicks, and Allen, and other economists. The fourth advance is due to the discovery of the correspondence principle. There are comparative statics analysis and comparative dynamics analysis according to whether the analysis is completed for a static or a dynamic model. When the system is stable, the comparative dynamics analysis is called the correspondence principle by Samuelson. In his *Foundation*, Samuelson foresaw what should be done in the future:

> A natural fifth step to take after we have investigated the response of a system to change in given parameters is to investigate its behavior as a result of the passage of time.

Inspirited by Haken's synergetics and Prigogine's works (Prigogine 1980; Prigogine and Stengers 1984) on dissipative structures, I generalized Samuelson's *Foundation,* analytically completing the fifth step with nonlinear science and modern computer. After having read the *Foundations* and *The Collected Scientific Papers of Paul A. Samuelson* (the volumes published by 1990) and other classical works in economics, I set myself a task to explore the fifty step of analytical economics unexplored in the *Foundations.* My *Synergetic Economics*, which was finalized and printed in the same day as my Umea Ph.D. dissertation *Economic Development* as research reports of Umea University in 1989, made a progress in analytical economics by examining nonlinear dynamic economic systems. *Synergetic Economics* was late published in Herman Haken's *Synergetics* series in 1991. My dissertation was published in 1990 with title *Economic Dynamics—Growth and Development* by Springer-Verlag.

Synergetic Economics was the first comprehensive book in nonlinear economics, especially in its explicit recognition as completing the fifth step of analytical economics. It contributes the development of the fifth step. Samuelson recognizes the significance of comparative dynamic analysis. But his generation could not create a theory of comparative dynamics in the contemporary standard. Nonlinear science and modern computer were not available then.

In contrast to Samuelson's traditional analytical economics, which is concerned with linearity and stability, synergetic economics emphasizes linearity versus nonlinearity, stability versus instability, continuity versus discontinuity, permanence versus structural change. Synergetic economics treats nonlinearity and instability as sources of the variety and complexity of economic dynamics, rather than nuisance and temporal phenomena as traditional economics does. According to synergetic economics, economic systems may run through a hierarchy of instabilities in which more and more structured patterns evolve. Such instabilities are caused by changes of external parameters and can lead to a new spatiotemporal pattern of the system.

A whole description of economic life needs genuine dynamic model which describes connected movements of every part of the entire whole. A genuine economic theory should be able to describe every individual behavior as an element of the entire economic system. There is no distinction between microeconomics and

macroeconomics as individuals live within the whole and the whole consists of individuals. The development of mathematics and computer provides powerful tools to explore complexity of genuine dynamical behavior. Nonlinear science gives a new vision about dynamic evolution. *Synergetic Economics* "completed" the fifth step because of the accumulated knowledge not only in economics, but also in natural sciences and mathematics. Synergetic economics marks the start of a new era of nonlinear dynamic economics. It shows the way in which economic systems far from equilibrium evolve elaborate structures: cycles, aperiodic motion, chaos, and well-organized time-dependent urban pattern formations.

Synergetic economics reveals how such interactions can bring about qualitatively new structures and how the whole is related to and different from its individual components. A modern computer can explore a far wider class of phenomena than it could have been imagined even a few decades ago. The essential ideas about complexity upon which synergetic economics is based have found wide applications among a wide range of scientific disciplines, including physics, biology, ecology, psychology, cognitive science, and sociology. Many complex systems constructed in those scientific areas have been found to share many common properties. The great variety of multiple applied fields manifests a possibly unifying methodological factor in sciences. Nonlinear theory offers scientists a new tool for exploring and modeling the complexity of nature and society. The new techniques and concepts provide powerful methods for modeling and simulating trajectories of sudden and irreversible change in social and natural systems. The range of applications of synergetic economics includes many topics, such as catastrophes, bifurcations, trade cycles, economic chaos, urban pattern formation, sexual division of labor and economic development, economic growth, values and family structure, the role of stochastic noise upon socioeconomic structures, fast and slow socioeconomic processes, and relationship between microscopic and macroscopic structures. All these topics cannot be effectively examined by traditional analytical methods.

The Samuelson generation had refined and developed the classical economic theories, but not in a unified manner. This book aims at unifying the well-developed theories in a comprehensive framework. It tends to do what Samuelson had envisaged long time ago:

> The usefulness of any theoretical structure lies in the light which it throws upon the way economic variables will change when there is a change in some datum or parameter. This commonplace holds as well in the realm of dynamics as in statics. It is a logical next, therefore, to begin to create a theory of comparative dynamics. This will include the theory of comparative statics as a special case, and indeed all of the earlier five subjects, but it will cover a much richer terrain.

This book explores "a much richer terrain."

1.2 Speed and Time Scale in Synergetic Economics

Synergetic economics attempts to provide a new vision of economic dynamics: a vision toward the multiple, the temporal, the unpredictable, and the complex. It tends to replace simplicity with complexity and specialism with generality in economic analysis. The concepts such as totality, nonlinearity, self-organization, structural changes, order, and chaos have found broad and new meanings by the development of this new science. Economic dynamics are considered to resemble a turbulent movement of liquid in which varied and relatively stable forms of current and whirlpools constantly change one another. These changes consist of dynamic processes of self-organization along with the spontaneous formation of increasingly subtle and complicated structures.

Even in basic economic courses, short-run and long-run phenomena are emphasized. An economic theory which tends to explain long-run economic evolution may be meaningless to explain short-run economic phenomena; similarly, the short-run Keynesian theory may be invalid for the long-run Schumpeterian theory of creative destruction. Orphanides and Solow (1990: 258) point out a fundamental problem of economics: "Short-run macroeconomics and long-run growth theory have never been properly integrated. It is only a slight caricature to say that once upon time the long run was treated causally as a forward extension of the short run, whereas nowadays the tendency is to treat the short run causally as a backward extension of the long run."

Before nonlinear science and computer were available, there was no proper tool for building a general nonlinear economic theory in which both short-run and long-run issues in microeconomics and macroeconomics can be analyzed in a single framework. Keynes (1883–1946) emphasizes the significance of studying short-run phenomena as follows: "But this *long-run* is a misleading guide to current affairs. In the long run, we are all dead." It is a common sense that before going to the long-run equilibrium state, death, the human body functions dynamically without going to any unique time-invariant point. The man's organ, health, preference, and human capital are constantly changing. These variables are all interconnected in dynamic ways within the same body. One may die in a few minutes if a subsystem, like heart or blood, disfunctions; a subsystem, like preference structure, has complicated relations with the other subsystems in the long term. No one can naturally avoid the aging process. To live a happy and long life, one take care of short-run as well as long-run health issues. Like human body, a human society is composed of different, such as fast like blood and slow such as bones, processes within closely interconnected whole. Long-run welfare and everyday pleasures are mingled together within an organic whole. Time is at the center of the chief difficulty of almost every economic problem. The role of time in decision makings and action is becoming increasingly complicated as variety of action and social networks are expanding. It is difficult to decide the length of time which affects a special decision making since each kind of human decisions are made with different time scales and two persons may have different time scales with regards to the same kind of decision making. One important

issue in synergetic economics is to explore relations between microeconomic and macroeconomic processes within different time scales. As time passes, economic issues with which economists are concerned have shifted. Even since the time of Adam Smith, the economic variables that economists have dealt with appear to have been invariant. But the ways in which these variables are combined and the speeds at which they change have constantly varied and the dominant economic doctrines have shifted over time and space. The complexity of economic reality is constantly increasing in modern time. This is partially because of the expanded capital and knowledge stocks of mankind and fast development of computer. Knowledge, in fields of philosophy, arts, literature, music, technology, and sciences, expands man's imagination and extends possibilities of human action. Knowledge is not only power and sources of money, but also the most durable capital good. Increases in machines, housing, and infrastructures have enriched human environment, increased accessibility to various locations, and enlarged variety of human behavior.

If one examines the complexity of economic evolution from a historical perspective, mankind has experienced three economic structural transformations—from hunting society to agricultural one, agricultural society to industrial one, industrial society to information/knowledge-based one. These transformations are still occurring in different nations in different forms at different speeds. Each of these economic systems has certain corresponding dominant ideologies such as religions, socialism, and capitalism. At each turning point, there tend to be great conflicts among different social classes, though forms of conflicts are affected by geographical conditions, cultural traditions, international environment, and other factors. As an illustration of applying the concept of speeds of changes in analyzing economic structural changes, I choose three variables, the population, capital, and knowledge. These three variables may be roughly considered to be changeable at different speeds in different societies. If one is interested in examining agricultural economies, one may concentrate on population (and power struggle) dynamics. But the analytical conclusions about agricultural economies cannot be applied to explain economic dynamics of industrialized economies, as capital is the dominant variable of industrial economies. Similarly, the analytical conclusions about capital-based societies cannot be applied to explain economic phenomena of knowledge-based societies as knowledge is also created and diffused very rapidly.

Another dimension in analysis is space. Man, action, capital, knowledge, and time can become culturally and socially meaningful only in certain space. Fast technological changes, richness of material living conditions, complicated international interactions, and many other modern phenomena have increased complexity of spatial economies. Without spatial dimension, one can hardly analyze actual processes of, for instance, how Japanese economy affects the world economy. In fact, the choice of spatiotemporal scale is a delicate process and must be made before actual study of any special economic problem. The explicit awareness of this necessity is very important for understanding both economic reality and structure of economics.

In synergetic economics, the key words are space, time, and structure. It is hard to give a precise concept of structure. Here, a structure means a sum of elements and relationships between those elements. In other words, structure stands for the way

the elements and constituent parts of a whole are arranged with respect to each other. Structure represents a whole in which each element depends on the others by virtue of its relations with them. According to Thom (1977), structure is defined as a spatiotemporal morphology described by significant spatial discontinuities and by the syntax that determines how these sets of discontinuities form into relatively stable systems. In evolving structures, relations depend on time. The structure includes properties, which are properties of the whole rather than only properties of its component parts. Any change in one element or one relationship will cause a modification in other elements or relationships. By means of the cooperation of the individual parts of different subsystems, new properties may emerge that are not present in the subsystems. Economic evolution involves not only changes in variable levels and functions but also in organizational structures that concern the way elements are connected within subsystems, the way subsystems are embedded in large ones, and the way that organizational structures emerge or disappear.

All these intrinsic difficulties related to economic structures heavily affect the efficiency of modeling economic systems. Multiple levels are described in long-term studies. This requires economic theory to have internal structures to represent the complexity of subsystems and connections of the subsystems. Such structural models will eventually turn out to be very complicated. A study of dynamics of a process on a level can thus be conducted by taking behavior of higher levels as fixed and "enslaving" behavior of the low levels as structurally determined flows. In other words, for the chosen time scale, the behavior of higher levels is so slow that they can be effectively negligible, and the behavior of lower levels is so fast that perturbations generated by the behavior of lower levels can also be effectively neglected. For instance, an economic analysis may be conducted in a time scale short enough to assume changes in ecological processes negligible and long enough to average out noise from processes occurring at individual levels. By the way, according to synergetic economics, in "revolutionary" periods or at such critical points, neither the dynamics of higher levels nor the perturbations generated by the behavior of lower levels are negligible. The model used to describe the dynamic interaction of the chosen subsystem is no longer able to provide reliable information about possible behavior of the subsystem.

As an illustration, a few classical economic theories are mentioned with the concepts of time scale and speed of change.

1.2.1 Adam Smith (1723–1790)

In the *Wealth of Nations*, Adam Smith was concerned with the forces that govern the relative levels of prosperity among countries and that cause differences between countries. He discussed the advantages of the division of labor and its dependence on the scale of activity and the extent of the market. Large-scale activity and extended

market permit specification and thus improve skills and labor efficiency. Technological progress, division of labor, and scale of market are interdependent. He emphasized the significance of free institutions under which people freely exploit the advantage of their skill and knowledge and resources. Adam Smith's economic theory with division of labor and competitive equilibrium, irrespective of positive dynamic elements, sets limits on economic growth. His theory of economic equilibrium has been supported by the modern competitive equilibrium approach, while his theory of division of labor is formally modeled in recent years.

1.2.2 Ricardo (1772–1823)

Ricardo's fame relies on his *Principles* published in 1817. Although his interest in economics began with reading Adam Smith, he emphasized manufacturing in studying national economy. He tried to establish laws which regulate what proportion of the whole produce of the society will be allotted to each of three—landowner, capitalist and worker—under the names of rent, profit, and wages, respectively. These laws show how the distribution will change at different stages of society. He was concerned with an economic system consisting of agriculture and industry.

1.2.3 Malthus (1766–1834)

Although Malthus was not the first to examine demographic problems, he developed a theory of population growth. By emphasizing the interdependence of population growth and food supply, his theory lent support to the subsistence theory of wages, which had important influences upon Ricardo, Marx, and Keynes. In the simplest form of the Malthusian growth model, the population grows at a constant rate times the population present, with no limitations on its resources. That is, $\dot{N}(t) = aN(t)$, where $N(t)$ is the population at time t and a is a positive parameter. Such a population growth may be valid for a short time, but it clearly cannot go on forever. Malthus was aware of uncertainty in economic evolution with endogenous population. He believed in the nonlinearity of structural relations, and their complicated multi-connected nature, even though he could not rigorously show consequences of nonlinear interactions.

1.2.4 Marx (1818–1883)

Central to both Ricardo and Marx's economics were issues of the fundamental determinants of relative prices, production and reproduction and the distribution of income among social classes. As Marx created a system that embraced almost all fields of

social sciences, his ideas about economic dynamics are quite beyond the scope of this study. According to Schumpeter (1954: 596), "Ricardo, the most unmetaphysical of theorists, introduced the labor-quantity theory of value simply as a hypothesis that was to explain the actual relative prices—or rather the actual long-run normals of relative prices—that we observe in real life. But for Marx, the most metaphysical of theorists, the labor-quantity theory was no mere hypothesis about relative prices." I will model income and wealth distribution between various classes, which is a generalization of Marx's ideas on economic dynamics.

1.2.5 The Walrasian General Equilibrium Theory

The general equilibrium theory is a system in which maximization of households' utilities and producers' profits yields consumption components as functions of prices. The population, capital, natural resources, and technology are fixed in this approach. Price dynamics are specified according to the Tâtonnement. I generally describe the system by

$$s\dot{X}(t) = F_X(X(t), P(t)), \quad \dot{P}(t) = F_P(X(t), P(t)),$$

in which X and P are, respectively, the output and the price of the commodity. I consider that the real variable is "slow." Setting $s = 0$, I get $F_X(X(t), P(t)) = 0$, or $X(t) = X(P(t))$. The functional forms of F_X are determined by the forms of utility and production functions. Substituting $X(t) = X(P(t))$ into the price system yields:

$$\dot{P}(t) = F_P^*(P(t)),$$

where $F_P^*(P(t)) \equiv F_P\{X(P(t)), P(t)\}$.

An important feature of economic structures is that they are intrinsically complicated at each level. Individuals, groups or clubs, regions and nations, even as they develop under similar conditions, are not the same. Detailed studies of their evolution have provided many examples of an intrinsic complexity. For instance, random fluctuations in tastes may affect microeconomic evolutionary processes on a large scale. The economic structure represents the values and principles of the economic organization. The system may be analyzed by dividing the whole system into different levels, each representing a subsystem, which consists of relatively uniform elements that interact with each other either in simple or complicated ways. To find and describe these interactions are the key elements for analyzing order and disorder at any given level.

1.3 The Time to Integrate Economic Theories

The multitude of books is making us ignorant.
Voltaire (1694–1778)

In the Foundation, Samuelson predicts what is important for analytical economics (Samuelson 1947): "The further development of analytical economics along the lines of comparative dynamics must rest with the future. It is to be hoped that it will aid in the attack upon diverse problems—from … even to the majestic problems of economic development." My focus in this book is on "the majestic problems of economic development." These problems are analyzed by designing a genuine dynamic economic theory which illustrates actual paths of development with fast and slow processes and long-term and short-term time scales within a single analytical framework. Different economic theories have been proposed to study economic phenomena of different economic systems. The conventional distinction is between micro (household and firm behavior) and macro (nationally or globally aggregated models). There are also intermediate stages such as interactions between the agricultural sector and industrial sector. It is important to build a theory in which micro, intermediate, and macrovariables are treated in an interconnected whole.

The traditional scientific strategy is to decompose the whole into simpler parts until one can deal with simple parts. Economics has tried to find simplicity in a complex reality by this strategy. Economic theories such as Walrasian equilibrium theory, neoclassical growth theory, and new growth theory are developed, independent of each other, even though they deal with the same economic reality. Various fields in economics live in isolation from each other. Students trained in one subfield often have not a shared understanding of the fundamentals of the others. Economists from each subfield do not converge upon a common framework but find themselves in divergent directions. Economists have made various assumptions about the underlying laws of economic systems. The essence of synergetic economics implies that traditional economic theories and ideas which are proved to be valid or insightful for certain speeds of change and certain time scales should be integrated in a greater whole. This book is to construct a general theory with the vision of synergetic economics.

Confronted with limitations of traditional economics, economists have tried to relax assumptions in traditional analytical economics by taking account of, for instance, imperfect competition, imperfect information, institutions, and irrationality into economics. Many theories have been proposed by taking some realistic aspects. One find disequilibrium macroeconomics, family economics, share economy, new growth theory, and so on. Economics has been split between partial and conflicting representations of the same economic world. Diverse economic theories have coexisted but not in a structured relationship with each other. Students majoring in economics are taught severally incompatible theories one by one in the same course. Economic theory has experienced crises, such as in neoclassical growth

economics and Keynesian economics. Crises also imply opportunities for improvement. Multiple representations of the same reality itself imply a higher presentation. In order to overcome incoherence among multiple economic theories, economics needs a general theory which accounts for the phenomena explained by different theories in a unified manner. It is important to draw together the disparate branches of economics into a single organized system of knowledge. Causal links between these theories makes one to bridge theoretical gaps that a subtheory may not be able to span. This book makes a theoretical integration of well-established economic theories. The integration is conceptual integration in the sense that I analyze economic phenomena in different subfields with a few common basic concepts and assumptions. The theoretical framework describes dynamic interdependence between capital, knowledge, population, preference, habit, environment, resource, economic structure, family dynamics, different markets, and exchange values. Although it is easy to say that population growth, capital accumulation, creativity, and knowledge utilization, preference changes, resources are the basic determinants of modern economic changes, it is not easy to build a theory which connects them within a single analytical framework under various markets.

In evaluating a new theory, Kuhn (1977) gives a few criteria as summarized by Zhang (1999: 402–403): "(1) accurate within domain; (2) consistent internally and with other currently accepted theories; (3) a broad scope allowing its consequences to extend beyond the particular observations, laws or subtheories it was initially designed to explain; (4) simple but able to bring order to the phenomena that in its absence would be individually isolated and, as a set, confused; and (5) fruitful to disclose new phenomena or previously unnoted relationships among those already known." When claiming that the book proposes a general theory, I pay attention to these five characteristics—accuracy, consistency, scope, simplicity, and fruitfulness. I am also aware of limitations of these principles in evolution of socioeconomic theories as emphasized by Kuhn and other scholars.

1.4 The Structure of the Book

This book develops a general economic theory. It integrates classical theories from Adam Smith to Keynes and formal (mathematical) theories by Nobel Prize laureates in economics. It also establishes important relations among economic variables unrecognized in the literature of rigorous economic analysis. It constructs the theory by proposing a series of models; each of them can be combined to form a more comprehensive model. It is intended to build an economic theory like the *Yi Jing* system. The book is organized as follows.

This chapter shows that it is the time to integrate well-developed economic theories and to build a grand economic theory. Analytical economics has experienced a revolutionary change in the last few decades. This revolution is caused, in association with fast development of computer, by nonlinear science, which is composed of many branches, such as synergetics, theory of complexity, theory of self-organization, and

chaos theory. The revolution enables economists to analytically treat an economy as an organic whole, rather than collections of separate and unconnected parts as in traditional analytical economics. Having been influenced by different branches of nonlinear science, I have started to apply nonlinear science to economics about 35 years ago and built a theory in analytical economics, named synergetic economics. The name came from synergetics created by Hermann Haken. My book *Syngenetic Economics* is a further development of Samuelson's magnum opus *Foundation of Economic Analysis*, which was constructed in the time when nonlinear science and computer were not yet well developed. My book does what Samuelson foresaw what should be done after his influential milestone: "A natural fifth step to take after we have investigated the response of a system to change in given parameters is to investigate its behavior as a result of the passage of time." I also show what synergetic economics imply for modern economics. I recognized that it is the time to build a general economic theory in which main economic theories are treated as special cases. I started this process more than 30 years ago and this book reports the main results of the endeavor.

Chapter 2 starts the process of constructing the theory by building a model, called the basic model in this book, similar to the Solow–Swan model with an alternative concept of disposable income and utility function. It defines the basic model and its relations with some core growth models in macroeconomics. The first two sections develop the basic model and examine its behavior. Section 2.3 provides a theoretical foundation for the utility function proposed by the author. Section 2.4 shows that the rational behavior of household in the basic model yields the same economic mechanism as in the Keynesian consumption function. Section 2.5 shows that the basic model generates the same economic phenomena as the Solow growth model if I specify some preference change. Section 2.6 shows that the basic model generates the same economic phenomena as the Ramsey–Cass–Koopmans model with some endogenous preference change.

Chapter 3 generalizes the Walrasian theory. The traditional theory is for a stationary economic system. Walras introduced saving and capital accumulation in his general equilibrium theory. But his treatments of capital accumulation are not proper, especially in the light of modern neoclassical growth theory. Ricardo's *On the Principles of Political Economy and Taxation* of 1817 makes a valuable contribution to economics. Applying the law of diminishing returns in agriculture, he makes important development of the theory of rent. His study shows how wages, interest rate, and rent can be determined within a compact theory. This chapter integrates Walrasian general equilibrium, Ricardian distribution, and neoclassical growth theories as an extension of the basic model proposed in Chap. 2. The chapter also introduces exogenous shocks to the general equilibrium and demonstrates how various business cycles are generated by different exogenous changes. The appendix generalizes the model in cases of multiple capital and consumer goods.

Chapter 4 introduces education and human capital accumulation into the basic model. Adam Smith argues that improvement in the productivity of labor has their origins in the large part of the skill, dexterity, and judgment. Human capital is a consequence of the division of labor. But the opportunities and incentives to which workers