COMPLEXITY AND SUSTAINABLE DEVELOPMENT

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Summary

This article examines some aspects of socioeconomic development in light of complexity theory. It examines some nonlinear interactions between economic systems, institutions, population growth, knowledge creation and utilization, and cultural values. Multiple possibilities of behavioral patterns resulting from these nonlinear interactions are emphasized. It is argued that when "sustainability" is referred to some concrete long-term "goals" in complicated dynamic systems, it is only under limited circumstances that man might be able to achieve them.

1. Introduction

Since industrialization has become a global phenomenon, an increasing number of commodities are available to an increasing number of people in the world. Industrialization has brought material affluence to an increasingly large proportion of the world's population. A cursory comparison of the living conditions of many economies in the world from the beginning of this century to the present reveals great material progress. One may ask whether it is possible for industrialized economies to continue living at high levels of material abundance and for underdeveloped economies to enjoy material progresses brought about by industrialization over long periods without disastrous consequences for social, moral, political and environmental systems. In fact, since the publication of the Club of Rome report, there has been an increasing concern over limits to economic growth in a world of finite resources. According to the World Commission on Environment and Development report of 1987 about one million hectares of productive dryland annually turns into worthless desert and more than 11 million hectares of forests are destroyed yearly. The burning of fossil fuels puts into the atmosphere carbon dioxide, which is causing gradual global warming. This "greenhouse effect" may increase average global

temperatures enough to shift agricultural production areas, raise sea levels to flood coastal cities, and disrupt national economies. Other industrial gases threaten to deplete the planet's protective ozone shield to such an extent that the number of human and animal cancers would rise sharply and the oceans' food chain would be disrupted. The productive power of the world economy is putting increasing strains on the resource-base and life-support systems of the planet and many of its species. It has been pointed out that if present trends of population growth, environment deterioration and resources usage are continued, the world's people will be poorer in many ways in the near future than in the present (Anthony and Radcliffe, 1996, Donella, 1998).

It is obvious that sustainable development cannot be dealt with without a dynamic vision since it involves not only the present but also the future. The purpose of this article is to examine issues related to sustainable development in light of complexity theory. Complexity theory involves the study of complex systems which are characterized by nonlinear interactions between many elements (Haken, 1983, Prigogine, 1997). It reveals how such interactions can bring about qualitatively new structures and how the whole is related to and different from its individual components. The study of complexity has been enhanced with developments in computer technology. 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 have found wide applications among a wide range of scientific disciplines, including physics, biology, ecology, psychology, cognitive science, economics and sociology. Many complex systems constructed in those scientific areas have been found to share many common properties. The great variety of applied fields manifests a possibly unifying methodological factor in the sciences. Complexity theory is bringing scientists closer as they explore common structures of different systems. It 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.

Complexity theory has found wide applications in different fields of economics (Rosser, 1991, Zhang, 1991, Lorenz, 1993, Puu, 2000). The range of its applications 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 socio-economic structures, fast and slow socio-economic processes, and relationship between microscopic and macroscopic structures. All these topics cannot be effectively examined by traditional analytical methods which are concerned with linearity, stability and static equilibria. This new science has changed economists' views about evolution. For instance, the traditional view of the relations between laws and consequences -- between cause and effect -- holds that simple rules imply simple behavior, therefore complicated behavior must arise from complicated rules. This vision had been held by professional economists for a long time. But it has been recently challenged due to the development of complexity theory. Complexity theory shows how complicated behavior may arise from simple rules. A typical example is chaos identified from the simple logistic map. Nonlinear economics attempts to provide a new vision of economic dynamics: a vision toward the multiple, the temporal, the unpredictable, and the complex. There is a tendency to replace simplicity with complexity and specialism with generality in economic research. 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. According to 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. The accidental nature and the presence of structural changes like catastrophes and bifurcations, which are characteristic of nonlinear systems and whose further trajectory is determined by chance, make dynamics irreversible.

This article examines issues related to sustainable development in light of complexity theory. The paper is organized as follows. Section 2 examines interdependence between sustainable development and population growth. Section 3 is concerned with relations between creativity, knowledge utilization and economic development. Section 4 addresses dynamics between environment and economic development. Section 5 examines the role of government in economic systems. Section 6 illustrates sustainable development and cultural values, using Confucianism as an example. Section 7 summarizes the paper, discussing sustainable development and complexity.

2. Economic Development and Population Growth

In the early 1800s the world population stood at one billion. As industrialization spread widely, the world population took until 1930 to reach two billion. However, by 1990, the world population had passed five billion. Demographers project that the world's population will double to more than 10 billion by 2050. This explosion of the population could not have been sustained without the expansion of the world economy. The growth of population is a major force for change in the contemporary world. It is determined by multiple factors and has consequences for the natural world and for the political order. It is often argued that since production and resources are limited, the world population is "over-supplied". But without sufficient population, the division of labor could not be thoroughly carried out and productivity could not be improved.

When discussing issues related to interdependence between population growth and sustainable development, one can hardly miss mentioning Malthus' *Essay on the Principle of Population* first published in 1798. In this book, Malthus regarded population dynamics as a main cause for both the hope and misery of mankind. The first edition was based on the few materials which were then within Malthus' reach. It was one-sided and too pessimistic, as Malthus soon realized himself. After the publication of the first edition, the book generated great interest and received strong criticism. Taking account of various comments, Malthus revised the book several times before his death.

Malthus established his theory on the basis of three assumptions. The first is that food is necessary to the existence of man. The second is that the passion between the sexes, and thus the urge to procreate, is necessary and will remain nearly in its present state. The third is that economic production was dominated by decreasing returns to scale. Malthus held that population tends to grow geometrically, whereas food supplies grow only arithmetically. Without any checking, population would double every twenty-five years. It would take only a few generations of geometric increase to outrun the food supply. In the long run, the world would live on the brink of starvation.

Adam Smith held that there is a positive connection between the wealth of a nation and living conditions of the lower orders of society. He argued that every increase of wealth tends to increase the demand for labor and to improve the conditions of the lower classes of society. Malthus agreed that the two subjects are closely connected. But he did not hold that Smith gave a sufficiently correct and precise statement about the nature and extent of this connection and the mode in which increasing wealth operates on the condition of the poor. According to Malthus, any policies that attempted to alleviate poverty would be futile due to the operation of this natural law. His population theory implies that paying relief would continue social and economic problems associated with poverty rather than solve them. Since per capita consumption level would always tend toward the subsistence level, any increase in consumption above that level would only cause the poor population to grow until the population achieved its subsistence level again. Moreover, according to Malthus, paying relief may worsen the economy as a whole. Since paying relief tends to increase the population and shifts wealth from more productive to less productive use, this altruistic desire tends to slow down the national economic growth.

By emphasizing the interdependence of population growth and food supply, Malthus' theory lent support to the subsistence theory of wages which had important influences upon later economists such as Ricardo, Marx and Keynes. By explaining poverty in terms of a simple interdependence between the population and the means of subsistence, the theory still provides important suggestions for economic policy in less developed countries. Malthus' economics is one of the first economies functioning with non-constant returns to scale. It is decreasing returns to scale due to population growth that drive the economic system to miserable situations. Malthus saw that the only limit to a geometric population increase was wide diffusion of deadly disease and starvation. Checking forces such as postponed marriages, sexual continence, a greater number of unmarried men and women, and a strict adherence to sexual morality would not be strong enough to prevent disasters. He could not imagine the use of birth control on moral grounds.

The record of world history since Malthus' time can be used to prove or disprove Malthus' conclusions about the relationship between economic development and population growth, depending on when and under what conditions the data were collected. The economies of Western Europe, North America and Japan have experienced simultaneous growth of the population and improvement in the standard of living in terms of the consumption of goods and services. There are many other economies which operate according to Malthus' economic dynamics. In those economies every increase in agricultural production is more than offset by a large increase in the population. It should be remarked that it is argued that Western economies are also faced with the Malthusian problems, but in changed forms in the future. The developed economies have seen major shifts in population structure. The numbers in the economically inactive age groups in their sixties or above are rising at a dramatic rate. An aging population is associated with increased longevity and decreasing fertility. The increase in longevity associated with improvements in public health and medical treatment has created a growing burden on social security systems. It is possible that a population with too many old people inflicts too great an economic burden on the shoulders of younger adults. Moreover, when these adults themselves grow old they will need to be supported by a further increase in young adults. This may result in a decline in productivity because of insufficient natural resources. On the other hand, the aging population may have a positive impact on economic growth. The aging population means

an extension of the market. If the economic system exhibits increasing returns, the enlarged markets due to aging populations may benefit society due to return-to-scale economies. Changes in age structure may affect overall productivity levels and consumption structures in complicated ways. The distribution of human capital may be changed due to changes in societal age structures. For instance, Sauvy argued that productivity would be associated with aging, but inversely. An aged population may have detrimental effects on the productivity of the young. The tax burden of the unproductive elderly would be a growing cost to the economy yet the society's opinions are much more strongly influenced by the elderly. The young become a minority. He argued that a population without children does not believe in the future and can hardly be expected to have the pioneering spirit. The aging social environment prevents the young from shaking the burden of idleness from their shoulders and from contributing all their vitality. The will to create and build may be weakened in an aged environment. He pointed out that traditional economic analysis had not foreseen a moral and material crisis resulting from demographic stagnation.

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Biographical Sketch

Dr. **Wei-Bin Zhang**, born in 1961, teaches and does research at Ritsumeikan Asia Pacific University in Japan. His main research fields are nonlinear economic dynamics, macroeconomics, regional and international economics, urban economics, East Asian economic development, Chinese philosophy, and ethics. He has published more than 100 academic articles. His books include *Economic Dynamics* (1990), *Synergetic Economics* (1991), *Knowledge and Value - Economic Structures with Time and Space* (1996), *Japan versus China in the Industrial Race* (1998), *Confucianism and Modernization* (1999), and *Capital and Knowledge* (1999), Adam Smith and Confucius - *The Theory of Moral Sentiments* and *The Analects*.(2000). A Theory of International Trade – *Capital, Knowledge and Economic Structures.* (2000).
He was brought up and received his university education in mainland China. He studied at Kyoto University in Japan for four years. He conducted research in Sweden from 1987 to 1998.