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Multiply Connected Topological Economics, Nonlinear Theory of Economic Growth and Its Three Laws, and Four Theorems on Knowledge Economic Theory

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Abstract - Using the similar formulas of the preference relation and the utility function, we propose the confidence relations and the corresponding influence functions that represent various interacting strengths of different families, cliques and systems of organization. Since they can affect products, profit, prices, and so on in an economic system, and are usually independent of economic results, therefore, the system can produce a multiply connected topological economics. If the political economy is an economy chaperoned polity, it will produce consequentially a binary economy. When the changes of the product and the influence are independent one another, they may be a node or saddle point. When the influence function large enough achieves a certain threshold value, it will form a wormhole with loss of capital. Various powers produce usually the economic wormhole and various corruptions. Further, we propose new nonlinear theory of economic growth and its three laws: Economic takeoff-growth-stagnancy law, social conservation and economic decay law, and economic growth mode transition and new developed period law. A corresponding figure is represented. The social open-reform is a necessary and sufficient condition for further economic development. Based on the main characteristics of knowledge economy, the four theorems on the knowledge economic theory are proposed, and the production function and basic equations are expounded. Some possible directions of the development on the knowledge economy and a sustainable development theory of new economics are discussed.

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1. B.R.Schiller, Essentials of Economics(Fourth Edition). McGraw-Hill Companies, Inc. 2002.

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I. Introduction

Now the economic crisis and the crisis of economics must face an indisputable reality for world. We hope a stable economic growth, but there is often market failure or government failure [1]. Schiller said [1]: "Macroeconomic theory is supposed to explain the business cycle and show policymakers how to control it. But something is obviously wrong." "We have not consistently achieved the goals of full employment, price stability, and vigorous economic growth. All too often, either unemployment or inflation jumps unexpectedly or economic growth slows down."

Generally, theory of economic growth and the sustainable development of economy, etc., all warrant research. Moreover, various corruptions of many higher managers appear again and again.

In mathematical economics the fixed-point theorems of topology are used to prove the Nash equilibrium for n-person games. Arrow and Debreu presented a general model of

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Walrasian equilibrium theory, and proved the existence theorem of equilibrium for a competitive economy by topology [2]. Then McKenzie [3], Debreu [4], et al., developed the competitive equilibrium theory. Differential topology is introduced into economics, and Debreu [5] discussed two detailed questions.

Usual economic theories include only some interpretation on pure market process. The public choice theory is a great economics that intersects the two disciplines: the institutions are those of political science, and the method is that of economic theory [6-8]. It applies and develops scientific economic methods to other social regions. The public choice theory emphasizes comparative institutional analysis and, in particular, by their concentration on the necessary relationship between economic and political institutions. But alternative institutions may also have defects.

II. The Confidence Relations, the Influence Function and Multiply Connected Topological Economy

In the classical economics various quantities may be classified to two types: 1).Quantitative quantities, for example, capital, labor, product and profit, etc; 2).Qualitative quantities, for example, management, policy and preference, etc. The later possesses some human subjective factors. The two respects intersect usually each other, such the economic systems often show more complex social phenomena.

In the microeconomic theory of consumer behavior either a utility function or a binary relation can describe the preferences of an individual. The strict equivalence of these two primitive concepts, ordinal utility functions and preference relations, was first axiomatized by Debreu [9,10]. He studies the concept of cardinal utility in three different situations by means of the same mathematical result that gives a topological characterization of three families of parallel straight lines in a plane [9], and discussed that for every continuous complete and transitive binary relation $\geq$ defined on an arbitrary subset X of the commodity space R, there is a continuous utility representation; that is, there is a continuous function u of X into R such that $u(y) \geq u(x)$ if and only if $y \geq x$. Therefore, the more basic concept of preferences is applied instead of utility by means of a topology or a metric on the space of preferences. Undoubtedly, it is a great contribution for economics.

The topological structure on the space of preferences is very useful. For example, Hildenbrand used the structure to describe an exchange economy by its distribution of agents characteristics: preferences and endowments.

Moreover, the solution to the static maximization problem in Bellman equation yields a policy function that gives the optimal value of the current control as a function $g_t(x_t)$ of time and the current state. So the tomorrow state in is given by $x_{t+1} = m_t[g_t(x_t), x_t]$, and a solution to a similar problem then yields tomorrow's optimal control [11].

In microeconomics we introduce the confidence relations that represent various interacting strengths of different families, cliques and systems of organization. It is an important human relation in economics, even is independent of economic results. The confidence relation can be defined by a similar method with the preference relation in consumer theory [12,13].

The confidence relation $\geq$ defined on the choice set X is a complete preordering, continuous and strictly monotone. This requires [11]

Ref.

2. K.J.Arrow and G.Debreu, Existence of an equilibrium for a competitive economy. Econometrica. 22, 265-290(1954).

(1). Reflexivity: $\forall x \in X, x \geq x$;

(2). Completeness: $\forall x, y \in X$, either $x \geq y$ or $y \geq x$ or both;

(3). Transitivity: $\forall x, y, z \in X$, $[x \geq y$ and $y \geq x] \Rightarrow x \geq z$.

Then $\geq$ can be represented by a real-valued, continuous and increasing payoff function.

Further, the definition of the influence function I is similar with the utility function: A real-valued function $I^i : X^i \to R$ represents a confidence preordering $\{\geq_i\}$ defined on the choice set X^i of agent i if $\forall x, y \in X^i, x \geq_i y \Leftrightarrow I^i(x) \geq I^i(y)$. The influence function that represents a confidence preorder is not uniquely defined. Any monotonically increasing transformation $\varphi(\ )$ of I( ) will represent exactly the same confidences, because with $\varphi(\ )$ strictly increasing, we have

$$I(x) \geq I(y) \text{ if and only if } \varphi[I(x)] \geq \varphi[I(y)], \tag{1}$$

for all $\forall x, y \in X$. Hence I( ) is an ordinal influence function. The sign of the difference I(x)-I(y) is important because it tells us which outcome is confided, but the value of this difference is meaningless, as it will change with any nontrivial increasing transformation $\varphi(\ )$. It is also a basic characteristic of topology, where those concrete spacing values are meaningless. Although the influence function is similar to the utility function that obeys the law of diminishing marginal utility, but the influence function seems to obey the law of augmenting lust for power.

The confidence relation, the corresponding influence function I( ) and the function $\varphi(\ )$ can affect products Q, profit and prices, etc., in an economic system. But, they are usually independent of economic results, and sometimes are stochastic, even change suddenly. In a continuous topological manifold of economics they break easily original structure, and form a new hole or branch region. This will construct a multiply connected topological manifold. In an image the economic structure is a cup, while the influence function is a handle.

In a multiply connected region of topology there is a famous Euler-Poincare formula

$$\sum_{m=1}^{n} (-1)^m a_m = \sum_{m=1}^{n} (-1)^m p_m . \tag{2}$$

For a convex polyhedron, a_0, a_1, a_2 denote the number of vertices, edges, and faces, respectively; p_m is the mth Betti number of complex K. This may be considered intuitively as the numbers of m-dimensional holes in K, or is the number of (m+1)-dimensional chains that must be added to K so that every free m-cycle on K is a boundary [14]. The number $\sum_{m=1}^{n} (-1)^m a_m$ is called the Euler characteristic of the complex K. In the polyhedron $p_0 = p_2 = 1, p_1 = 2p$, p is the deficiency of a curved surface. In 2-dimensional curved surface, $a_0 = a_1 + 1 - 2p$. Assume that vertices represent the number of

Ref.

14. J.G.Hocking and G.S.Young, Topology. Addison-Wesley Publishing Company, Inc. 1961.

market, which is direct proportional to the sales volume y and the profit, and edges represent the market network. But the multiply connected economy brings the profit decrease. In this case there is a defective profit due to the deficiency p.

In some systems of organization the profit maximization and the confidence relations are inseparable. The aim of a pure producer is the profit maximization

$$\pi(y,w) = \max_{x,y}\{py - wx\}, \tag{3}$$

where y and x are output and input, p and w are output and input prices. For a social system with the influence function I, we should define an aim function as

$$A = \pi + I. \tag{4}$$

The objective function $f(x;\alpha)$ gives his payoff, when he faces environment α and chooses action x [11]. Usual profit is

$$\pi(Q) = TR(Q) - TC(Q), \tag{5}$$

where $TR(Q)$ and $TC(Q)$ are the total revenue and the total cost, the three quantities all are the functions of products $Q=f(K,L)$. Now the maximum principle is the aim function maximization. The initial condition of the profit maximization is

$$\frac{d\pi}{dQ} = \frac{dTR}{dQ} - \frac{dTC}{dQ} = 0, \tag{6}$$

$$\therefore \frac{dTR}{dQ} = \frac{dTC}{dQ}, \tag{7}$$

i.e., $MR=MC$, the marginal revenue equals to the marginal cost. While now we derive a new result:

$$\frac{dA}{dQ} = \frac{dTR}{dQ} - \frac{dTC}{dQ} + \frac{dI}{dQ} = 0, \tag{8}$$

$$\therefore MR - MC = -\frac{dI}{dQ} < 0. \tag{9}$$

In the social system the aim function deviates the profit maximization, which is defective usually since $MR - MC < 0$.

The production function in the traditional theory of the firm expresses output Q as a function of two inputs: capital K and labor L,

$$Q=Q(K,L). \tag{10}$$

The profit maximization of the firm is

$$\pi = pQ - mK - nL, \tag{11}$$

where p, m and n are the prices of output, capital and labor flows respectively [15]. If the influence function regards as a condition of the economic system, the economic meaning of the influence function will also be able to be discussed using the Lagrange method of conditional maximization.

III. Political Economy, Singularity and Wormhole

Notes

A complete market economy should be a simplex free economy. But, a non-market economy, and any oligarch economy must be a multiply connected topological economy, which changes to a higher dimension, for example, it will add a new dimension with man-rule. This economy may be dismembered and comminuted, and has various holes and be mangled easily for distortions.

According to <Oxford Advanced Learner Dictionary of Current English> the political economy is study of the political problems of government. It as an early title is very famous, for example, David Ricardo's <The Principles of Political Economy and Taxation>(1817), Thomas Robert Malthus' <Principles of Political Economy>(1820) and <Definitions of Political Economy>(1827), James Mill's <Elements of Political Economy>(1821), and Karl Marx's <The Critique of Political Economy> and so on. The political economy now sounds old-fashioned but usefully emphasizes the importance of choice between alternatives in economics which remains, despite continuing scientific progress [16].

If the political economy is an economy chaperoned polity, it will produce consequentially a binary economy. Its basic group is different with a complete market economy in the algebraic topology.

A general change of the supply-demand function is

$$\frac{dQ_d(Q_s)}{dt} = f(Q_d, Q_s, p) + V + S. \tag{12}$$

Here V is a governmental potential, and S is a stochastic factor. The equation (12) has the outside force and the potential V, such the economic results change along with different V. If V is inequitable and factitious, the results will possess bigger stochasticity.

Various powers are some different attractors, and produce the economic wormhole and various corruptions. In particular, if the multifarious confidence relations exist, a whole economic system and corresponding topological manifold will be covered with many big and small holes like bruises and scars. In this society the highest economic aim is only the confidence relation for families, cliques and systems of organization. Some big or small powers cling to an economic system, and form the multiply connected topological economy, and have a series of corruption with the self-similarity. It is a special type of the fractal economy. There is a binary economic function of power-business. Both is usually asymmetry, i.e., is inequality. Under this system various aspects tend spontaneously to the breaking of symmetry. An imperium is an economic black hole, which will derive the huge corruption, and finally the system dies out.

The political economy should be a pair coupling equations on polity and economy. Assume that a potential is $U = 2aX^2Y$. Here X is a confidence relation, Y is an economic benefit, and a is a coefficient. From this the difference between a theoretic value and a practice value will be estimated.

When the politics is put in command, the economy and its equation will be neglected. But, when oligarch notices the social crisis, the economic rules will be obeyed

more. Both alternation exhibits a periodicity. If they conflict, the result will be reform for the economics bigger than politics, or be retrogression for the economics smaller than politics.

The political economy is usually imperfect economic question, even completely is not an economic question for some particular cases. It is not a strict economic rule, because in this case economy is only an appendage of polity. The economy will change along with polity.

The multiply connected topological economy may be extended to various relations between economy and other politics, family, religion, etc. Further, it may be developed to many regions of without direct relations with economy, for example, welfare, environment, and full employment, etc.

If the influence function changes as time, the system will be more complex. Assume that the economic system and its change are linear [11]:

$$\frac{dQ}{dt} = a_{11}Q + a_{12}I\,, \tag{13}$$

$$\frac{dI}{dt} = a_{21}Q + a_{22}I\,. \tag{14}$$

Their characteristic matrix is

$$\begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}. \tag{15}$$

The corresponding characteristic equation is

$$\lambda^2 - (a_{11} + a_{22})\lambda + (a_{11}a_{22} - a_{12}a_{21}) = \lambda^2 - T\lambda + D = 0\,. \tag{16}$$

From this we may discuss the general cases. As the simplest example, if the changes of the product and the influence are independent one another, i.e., $a_{12} = a_{21} = 0$, the solutions of the equations will be $Q = Q_0 \exp(a_{11}t), I = I_0 \exp(a_{22}t)$. $\Delta = T^2 - 4D = (a_{11} - a_{22})^2 \geq 0$ for a real domain.

When a_{11}, a_{22} are real numbers of the same signs, $D>0$, the state (Q_0, I_0) of the system is a node point, which is stable for $a_{11}, a_{22} <0$, and is unstable for $a_{11}, a_{22} >0$ (Fig.1).

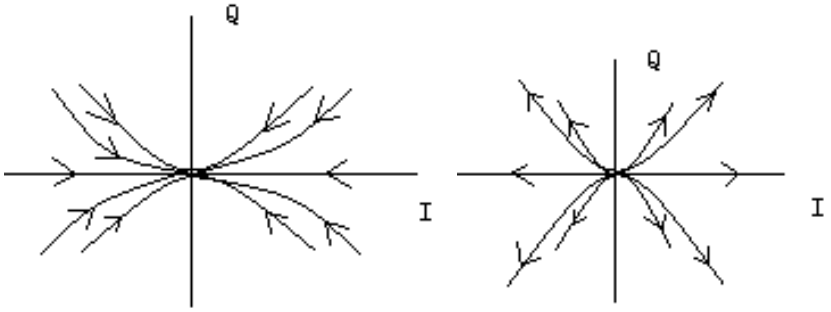

Fig.1 : Stable and unstable node points

Ref.

11. A.de la Fuente, Mathematical Methods and Models for Economists. Cambridge University Press. 2000.

When a_{11}, a_{22} are real numbers of opposite signs, $D<0$, the state (Q_0, I_0) of the system is a saddle point (Fig.2).

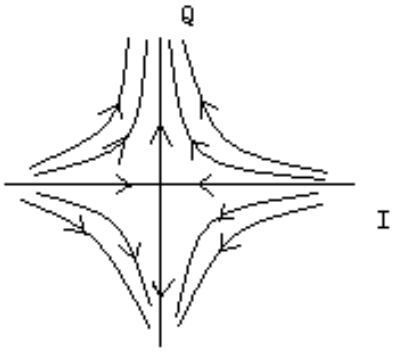

Fig.2 : Saddle point

It represents that product increases and the conference decreases. If the two changes of the product and the influence intersect one another, the states of the economic system will be able also to be the spiral (focal) point, or center, etc.

The form of the influence function can be an unrestricted function, even a stochastic function. Perfect competition prevails that each producer and consumer regards the prices paid and received as independent of his own choices [2]. An economy with the confidence relations and the influence functions is a type of imperfect competitive economic systems, and break the symmetries in economic topology. They are not homeomorphic spaces. Usually this structure will hinder the economic development. If the confidence relations and the influence functions have p -levels or p-types, i.e., $\sum_{i=1}^{p} I_i(Q)$, they will construct a multiply connected normal curved surface with the deficiency p. When the influence function large enough achieves a certain threshold value, the economic elasticity of topological structure will be broken, and a new hole will appear. Unified market economy will be riddled with holes. This will form a new multiply connected topological manifold. As an example, using the concept of general relativity a large influence as mass of general relativity forms a pit in the economic system. According to Fuller-Wheeler theory [17], a very strong pit can construct a wormhole, sometimes called the Einstein-Rosen bridge [18]. Therefore, some capital will pass through a throat into another topological space, or from a region to another region in the same space (Fig.3). This model will may describe a loss of capital (including waste, and corruption).

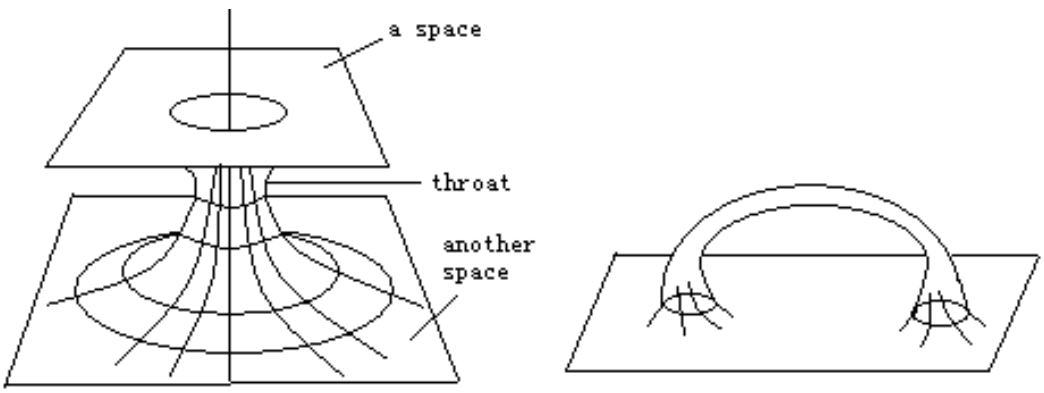

Fig. 3 : The wormhole model in social economics from a space into another topological space, or from a region to another region in the same space

Ref.

17. R.W.Fuller and J.A.Wheeler, Causality and multiply-connected space-time. Phys.Rev., 128,919- 929(1962).

In a word, the confidence relation and the influence function provide the useful tools for a description of human activity in economic system. This method of the multiply connected topological economy can be extended to various aspects on polity-law, on polity-education, on government-people and so on.

IV. Nonlinear Theory of Economic Growth and its three Laws

The theory of economic growth is very important in modern economics [19]. Solow's classical growth model of dynamic economy [20] and its extensions, for example, the theory of endogenous growth and so on [21]. These form the neoclassical growth theories [22].

I think, growth in any economic system with large and increases speed is a linear growth theory, but this is completely impossible for longer time, no matter what for circumstance, resources, markets, or populations. It has been proved time after time by the economic growth of many countries in world, and does not agree with a universal rule of scientific development.

At present, the theories of economic growth not only cannot forecast various economic crisis, and possess many theoretical questions [22-26], for example, some suppositions [25] and the basic equation in Harrod-Domar theory of economic growth [27,28,25]:

$$\dot{k} = sf(k) - nk\,. \tag{17}$$

Then various extensions of the neoclassical economic growth model are proposed, for example, Cobb-Douglas production function [29,30]:

$$Y = AK^{\alpha}L^{\beta}\,, \tag{18}$$

and technological change and innovation, etc. [19,31]. Beine, et al., discussed the relations between brain drain and economic growth [32].

Because the development and change of whole society are very complex and should be nonlinear, the static and stable growth all is impossible. In the economic system much complex and nonlinear processes exist. For instance, Boldrin and Montrucchio proposed that the optimum growth method is possibly nonlinear chaos [33]. Therefore, we propose a nonlinear theory of economic growth. Assume that the evolution and development equation for a corporation is [34]:

$$dF/dt = EF^{m} - BF^{n} + \Gamma(t)\,. \tag{19}$$

Here F is the selling price with a certain gain, and $\Gamma(t)$ is a stochastic term. Its change with time should be direct proportion with m power (force) of F and the fact throughput E, but will diminish along more increase market (assume it direct proportion with n power of F). For the corporation the two aspects are respectively beneficial and unfavourable, or are called common promotion and common restrain [13]. Let m=1, n=2 and $\Gamma(t)$=0, Eq.(19) will be simplified to an equation:

$$dF/dt = F(E - BF)\,. \tag{20}$$

Ref.

20. R.M.Solow, A contribution to the theory of economic growth. Quarterly J.Economics. 70,1,65-94 (1956).

Its solution is:

$$F = \frac{E}{B(1+Ce^{-Et})}. \tag{21}$$

Since the fact throughput E may express as following:

$$E = E_0 - ST, \tag{22}$$

in which E_0 is an immanence ability of corporation (it includes personnel, equipments and fund, etc., of corporation), the extensive entropy S is a disorder scale in corporation (it shows technique, managed level, rationalization of combination on personnel and so on). The extensive temperature T is defined the drain of corporation, which includes operating costs, laborage, welfare and revenue, etc. From this we obtained seven conclusions [34].

We think that the nonlinear evolution is a universal rule for economic growth. While the development of corporation is also an important base of economic growth, therefore, these conclusions may be extended to apply to the economic growth theory, and propose the three laws:

First law: Economic takeoff-growth-stagnancy law. Any output and corresponding economic development all must pass a general nonlinear evolutional process from takeoff to growth and stagnancy, no matter what for various merchandises or any country. It is unreasonable and impossible that anybody requests a persistent linear growth of economy.

Some concrete statements are: Since the economic development is related with the social throughput, whose quantity is connected with this social immanence ability E_0. When the social immanence ability E_0 is invariant, according to (22) only the higher order may decrease S amount, or decrease drain T, the both methods can increase the social throughput E and the developed level F. But, the decreasing S and T cannot be infinite, both all have the minimum. It corresponds to the maximum of the social effective throughput. This is a maximum F=E/B of developed limit when time t increase continuously. It is a stagnancy dates of economic growth.

Second law: Social conservation and economic decay law. For any society, since the original throughput outmoded gradually, the social ageing, the saturated marketplace; contrarily, employment, laborage, welfare, operating costs, etc., will increase continuously, S and T reach the minimum then will raise, and add the resources consumed, the wastes increased, the environmental largeness press and so on. Such the corresponding social effective throughput E and the original economy develop to a certain extremum, and will descend inevitably.

Third law: Economic growth mode transition and new developed period law. Further development of social economy must exploits new merchandise and market, and adjust output configuration, and reform technique, and train personnel, so that boost up the immanence ability of social development and the international competitiveness. At the same time, the social framework and various personnel must readjust combination, and the management level raises up to follow the social development and new talented persons, new equipments, new outputs, new techniques and new capital introduced. Such the society should reform continuously to achieve a higher seedtime. This is namely to search new economic growth point for microeconomics. It corresponds to a development of the paradigms in science.

Ref.

34. Yi-Fang Chang, Social Synergetics. Science Press.2000.138-140.155-161.

The three laws on economic growth may be represented by Figure 4, in which CA expresses the first law, AA' expresses the second law, and AB expresses the third law. It should be a medium-time mode of economic growth, and is also three developed phases of social economy. Point A and dotted line are related with the limits to growth [35]. The third law connects to "the quality ladder"[22], which expresses a new period of development. The second law expresses a seasonal recession. They agree with Lotka-Volterra model in ecology, and are two different foregrounds of economic evolution, and are two-bifurcation phenomena of nonlinear system. An infinite clone of the same developed mode will derive a disorder competition, and finally reach necessarily to chaos and economic crisis. Therefore, the nonlinear chaos economics is possibly related with the crisis economics.

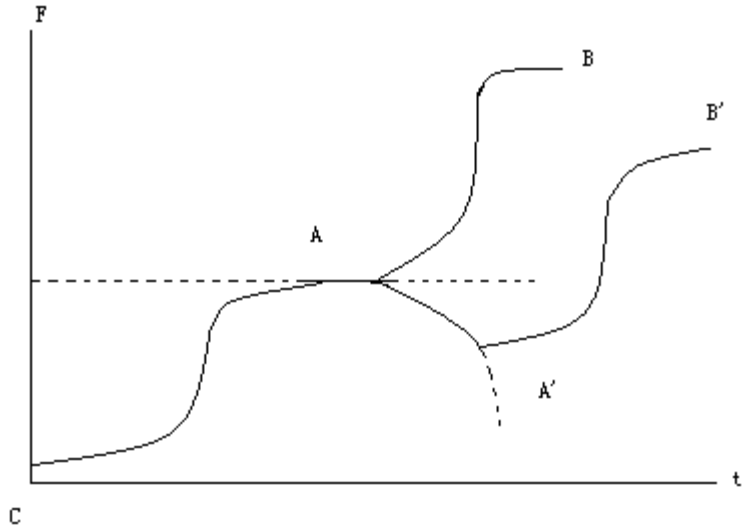

Fig. 4 : The three laws of economic evolution

It may combine the theorem of transformation from energy to quality on social development [34,36]. Rivera-Batiz discussed the relation among democracy, governance and economic growth [37].

In a word, social open is a necessary condition for economic further development, but it must add corresponding social reform as a sufficient condition of economic development [26].

V. Economic Theory and Its Four Theorems on Knowledge Economy

A production function in the classical economy is $Y = F(K, L, X_i)$. A well-known economic theory on the industrial economy is the input-output model, whose mathematical basic is matrix and linear algebra. New epoch of knowledge economy shows a new paradigm of economic growth.

Based on the main characteristics of knowledge economy and its similarity with the information theory, we proposed the four theorems of the knowledge economic theory [38,39]:

1) The innovation theorem by talented persons. The knowledge economy is innovative economy, in which talented persons are the most important. Labor and capital will fall to second roles.
2) From zero to things theorem. This is a process of information translated into substance and wealth. Its mathematical representation is $\int 0\,dT = C$.

Ref.
35. D.L.Meadows, et al., The Limits to Growth. New York: Universe Books. 1974.

3) The increment theorem by cooperation. A main character is networking in knowledge economy, which must emphasize cooperation in a system. For the economic development it includes an exponential change law $F = Ce^{at}$, here the innovative index $a > 0$. This may mathematically apply the Haken's synergetics [40].
4) The continuous cycle theorem. The output of knowledge economy possesses very high scientific and technological content, so it is light and corresponding waste is also little. This theorem includes two aspects: (1)Since the capital is smaller, so that the required natural resource and corresponding waste are also very little, therefore, it is a model of sustainable development. (2)Much riches may be created due to talented persons, and capital can attract more talented persons, such it will enter a fine cycle. This can use Eigen's hypercycle.

These theorems are also a developed process, in which theorem 1 is basic, which corresponds the human capital investment in neoclassical growth model, and other theorems are some results of innovation and development.

For the epoch of knowledge economy, knowledge is first in various bases, talented person is first in various resources, innovation is first in various developments, and cooperation is first in various managements. Its precondition is a right decision-making, which requires confirming a developed mode and a choice function. The talented person is only an order parameter for the new epoch. The production function will be simplified to an approximate single variable function Y=F(T). It is the most important mathematical character on knowledge economic theory. The talented person is a mostly stanchion, and knowledge and information are the most important and the essential production factors. The worth of knowledge is a scale of developed level on the microscopic knowledge economics. The innovation is a core and spirit, and is not a simple clone and expanded reproduction.

The basic mathematical model for the knowledge economy is nonlinear theory. In this case, the Cobb-Douglas production function [29,30] (18) will become to $Y = BT^{\alpha}$, in which α is an index on the talented person, and it includes the amount and quality of talented person, and $\alpha = 0$ is a point of phase transformation. Assume that a change equation of output is:

$$dY / dt = a(T)Y . \tag{23}$$

Its solution is $Y = C\exp[\int a(T)dt]$. When $a > 0$, the economy will show an exponential growth [38]. We think that topology and its tools in this economy will exhibit larger function due to networking of the epoch.

Further, the knowledge economic theory should develop a model of the simultaneous algebraic or differential equations, which are probably applied to describe the macroeconomic configuration of the large system. The epoch of knowledge economy will really realize Francis Bacon's well-known maxim: Knowledge is power!

In economic topology, the economic equilibrium states are some stationary equilibrium regions in the static economics. Based on the east thinking-system, especially, I Ching (Yi) and Lao-Zhuang philosophy, we proposed a sustainable development theory of new economics and its three principles: the common restraint or common promotion principle of the Yin-Yang and the Five-Elements, the whole principle of heaven-humanity-earth, and the cycle principle of some elements. Its major characteristics are entirety, balance and harmony. The highest aim is the principle of unified nature-human-

Ref.

40. H.Haken, Synergetics. Berlin: Springer. 1977.

society harmony [13,41]. From this we may research the corresponding mathematical theories and some concrete applications, and Chinese traditional agriculture and farm are a classical type of the complete recycling economy [41].

The economic theory of knowledge economy combined new economics of sustainable development and the nonlinear theory of economic growth will be able to form the nonlinear whole economics, which may apply a similar method of the nonlinear whole biology [42,43].

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