Hitotsubashi Journal of Economics 49 (2008), pp.133-147.

PRELIMINARY CONCEPTS FOR ECONOMIC SYSTEMS ANALYSIS

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Accepted September 2008

Abstract

In preparing theoretical tools to analyze economic systems we need several fundamental concepts that are often applied in various scientific investigations outside economic studies. Amongst others, the concept of *autopoiesis*, which was introduced by Niklas Luhmann into his sociological systems theory, is the most important in constructing a theoretical model to explain the working of economic systems. An *autopoietic* system may be regarded as the functional core by which other elementary concepts such as homeostasis, machinery, corporate system and social entropy can be logically connected.

In conclusion, all economic systems are contained in distinct social systems of autopoietic character and incorporated with them as a subsystem or partially independent system.

Keywords: system, autopoiesis
JFL Classification: B00, B41

Since the 1970s the sociological importance of the system concept based on general systems theory has been emphasized in the reconstruction of fundamental methodological concepts such as 'structure' and 'function', and consequently several significant issues concerning its application to social sciences have been raised by sociologists and social philosophers.[1] Amongst others, Niklas Luhmann, a German sociologist and philosopher, constructed a far-reaching framework of social systems theory.[2] In the present article, we apply his social systems theory to the sphere of economic systems. Our aim is to universalize and formalize the perspective of social systems theory, and then to redefine the concept of system so that it is efficiently applicable to any economic systems analysis. As a result, we propose a new socioeconomic or metaeconomic view for interpreting all economic phenomena.

[1] See, 'Einleitung' in Bühl (1975).
[2] We refer to his article ('Funktionale Methode und Systemtheorie' in Bühl (1975)) and his two great books (Luhmann (1984) and (1988)).

I

The process of creating an image of a structure involves transforming the initial object of thought to another object through the field in which we are constantly operating our thinking apparatus. Professional mathematicians recognize this process to be an operation in a 'category' that is a collection of objects and morphisms or an axiomatic schema of sets and mappings. More generally, it is a process of forming an imaginative relationship among objects of intellectual speculation. Jean Piaget, a Swiss psychologist, called its product a 'constructive structure' that is characterized by the criteria: 'totality', 'transformation' and 'self-regulation'.[3] On this occasion it must be noted that the existence of a 'constructing' structure precedes that of a 'constructed' structure, since the latter cannot be considered as an *a priori* object of thinking as in the epistemology of naïve realism.

On the other hand, the same process is also able to be conceptualized formally. It seems that the word 'system' is entirely appropriate for it. If we regard any apparatus of operation in general as an operator irrespective of whether it is worked by human beings or physical machines, and consider the initial object that is worked on by the operator and the final object produced by it as input and output, we can represent the 'constructive structure' by the 'input/output schema'[4] which is logically equivalent to the structure of mathematical 'category'. Particularly in view of the fact that Piaget emphasizes the importance of 'self-regulation' in the notion of structure, the extended concept of system with feedback and feed-forward may be more suitable for our intended purpose. Therefore we remark on some elementary points concerning the concept of operation.

First, we introduce several terms in relation to feedback control. A set of governors, each of which forms an individual system, may belong to the—usually, multi-level—*control sphere* that operates on the *real sphere* where there is a vertical or hierarchical relationship among functionally different systems. Then we add a brief explanation of the term *feed-forward control*, which is closely related to feedback systems. It is a control that can be operated in the time-pass between the initial input and the final output within a certain complex system. Its marked characteristic may be revealed in the function of cutting off some external disturbances or influences of outside systems. The concept of feed-forward seems to play a crucial role in the functional analysis of social organizations. In particular, we take note of negative feed-forward, which controls information oppressively in the time-pass between input and output. Examples include the restraint of human behavior by a rumor or canard, the self-imposed control of low-level government clerks against an order by a senior officer, the suspension of speculative activity under a pessimistic prediction etc. Moreover, feed-forward control is especially significant in the case of a game-like situation, since it includes an element of social or mutual prediction as an indispensable part. Its predictiveness may be derived from the reflective process that is initiated in view of the consequence of feedback control. If we drive a car without feed-forward control and put on the brakes after a car crash, we may be killed in the accident.

Apart from the descriptive or technical aspects of the system concept, we examine its more

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[3] See, Piaget (1968).

[4] Luhmann (1984), S.24.

formal and theoretical structure, which may be symbolically called the 'input/output schema'. Structure is formally composed of a collection or a set of symbols or elements and one or more fixed relations among them. Structure itself is independent from any space-time constraints, since it has no temporal or spatial character. In a more metaphysical expression structure is static, while system is dynamic. But the latter must be defined more strictly. The concept of system is subordinate to that of structure. System is a certain kind of structure that includes a temporal order, and therefore it is a moving, continuous and sometimes infinite structure. The above expression 'input/output schema' or more precisely 'input/operator/output schema' may be convenient for elucidating such a definition. Accordingly a feedback system performs the function of inverting the temporal order and maintaining the partial reversibility of the system as a whole. If we adapt the concept of system to a logical framework of mathematical 'category' theory to be given later, the notion of input and output may become an efficient means for understanding the connection and separation between system and environment. Since the system is structure in motion, no system can exist as such when it stops motion and then it is to be reduced to a structure. For the description of motion as an essential element of system the expression 'self-reference' has often been used in social systems theory. It is a momentum or 'principle' to preserve the unity of a certain system. As is mentioned later, self-reference is the logical starting point from which an autopoietic system can be derived.

If we assign input, output and operator to domain, codomain and morphism in category theory, we can combine these sets to specify what Luhmann called the 'system/environment difference'.[5] When it is supposed that domain equals codomain, all elements of system shall belong to the same environment where the motion of system continues repeatedly and its openness, closeness and recursiveness may appear. It should be noted that 'environment' is sometimes replaced below by 'field' which is synonymous with it.

In consideration of the above terminology we examine a more concrete meaning of system in some cases of the observation of physical and social phenomena. Of course, no society can be regarded as a set of homogenous physical particles as in the quantum field. What is the difference between social and physical objects of observation?

Any individual person as a social 'particle' may have consciousness and create an image or a mental structure that is formally constructed by his morphism. A human action composed of several 'constructive structures' and mutually exchanging morphisms cannot be found in the motion of physical particles. Moreover, anyone can select and determine to specify morphism, and consequently recognize that there is a certain type of morphism ('function') between physical objects. Such mental activity of mankind may be called *observation*, which is a finite action that produces a tangible image of external phenomena. However, human beings cannot observe all objects of the phenomenal world. For example, we have no apparatus of observation for looking at the motion of particles in an eight-dimensional space. As a result we are faced with the limited choice between the recognition of the actual existence of a particle through its projected image in a four-dimensional space and the observation of an imperceptible object with its formal image such as a hyper surface represented by an abstract system of equations.

In physics, a certain pattern of interaction among particles has been grasped by the method of Hartree-Fock approximation. But it is much more difficult in social sciences to frame a law that adequately explains a mechanism of social interaction, since everyone is directly or

[5] *Ibid*, S.25.

indirectly influenced by other people's constructions, choices and determinations of morphisms for their own behaviors. Therefore, most social scientists assume that everyone is more or less alienated from society, which is principally based on the reification of social relationships, and build up a virtual image of society without human free will, where human communication takes place as if it were a physical phenomenon. On the other hand, the social systems theory elaborated by Luhmann constructs an image of society with free will. He supports his theory with two basic concepts: problem-solving and environment. We next consider his theoretical framework and explore its implications.

II

Here, we begin to disclose the structure of the problem. It may be suitable for an application of the system concept, since it is supposed to have a solution as a complex of operator and output. As Luhmann points out, the fundamental significance of the system is given by the function of problem-solving[6]. More accurately, the system has a functional structure in which arbitrary, sometimes mutually inconsistent problems are inputted and their solutions can be furnished as output through an operator. In this respect the system can be defined as a continuously moving dynamic structure. Of the several types of system that can be assumed, the following two examples have some explanatory significance.

[1] Problem-solving in mathematics

A diagram of the system can be made to show concrete problem-solving as follows:

domain (input) specified by raising a question
↓
morphism (operator)
↓
a set of solutions (output).

Another diagram of the system in a proof is also drawn:

specified sequence of symbols (input)
↓
combinations of axioms and theorems (operator)
↓
final sequence of symbols (output).

[2] Problem-solving in a criminal trial

In this case we can draw the following diagram with two opposite types of output:

prosecution (input)
↓

[6] Niklas Luhmann, 'Funktionale Methode und Systemtheorie', in Bühl (1975).

presentation of a case compared with structural elements (operator)
↓
the prosecutor's recommendation regarding sentencing (output 1)
The traverse of the recommendation (output 2).

Then the succeeding system works as follows:

input (output 1 and 2)
↓
consultation between judges (operator)
↓
the sentence (output)

Of these two cases, the former may be more formal and substantial. Any formal problem-solving in mathematics is immediately reduced to a substantial one. On the other hand, formal elements are separated from substantial ones in judicial problem-solving. Linkage between formal and substantial problem-solving attaches an actual meaning to legal judgments, since any formal problem-solving without a substantial one becomes meaningless in court. Such a 'linkage-viewpoint (*Bezugsgesichtspunkt*) [7]' of legal semantics enhances the substantiality of problem-solving in judicial decisions.

However, the formalization of social semantics that depends on a communicative structure of society may make any substantial problem-solving insufficient. If our social communications become diverse and isolated, we can only achieve a dry and mechanical problem-solving with no humane sensibility. A formal, but insubstantial problem-solving may be said to be a freeze on a problem. It is logically equivalent to a stop to operations in a machinery system. But it should be noted that a freeze on a problem can often be regarded as a 'solution'. Then we can suppose the third case that there exists no solution both formally and substantially. This means elimination of the problem or extinction of the operator. While putting off discussing this case, we next trace the relationship between problem-solving and a freeze on problems.

We can explain the moving pattern of a social system through a 'problem' by comparing two types of social relation or organization. For example, there may be various conflicts in the relationship between husband and wife. The relationship is based on sexual relations that are common to all living creatures. However the uniqueness of the relationship is that each member of the couple freely exchanges a vivid and unabridged imagination with the other to maintain the relationship through problem-solving. This system is not working if the number of unsolved problems that are decisive for the couple mounts progressively, and sometimes breaks down. Then the couple gets divorced. But even if divorce is avoided and the marriage continues, the marital relation cannot exist forever, since both partners will ultimately die. On the contrary, there is another type of social system that remains logically in perpetuity. For example, a joint stock company may have a continuous existence as a legal entity, because it is operated by shareholders and functional members who are interchangeable and can be recruited irrespective of the death of individual persons. The fate of a joint stock company as a system is mainly decided by the cumulative effects of a freeze on problems. For instance, any corporate failure

[7] *Ibid*., S.121.

owing to an accumulated debt ('problem') may endanger the existence of a joint stock organization. Such an organization seems to be a representative type of social system. Therefore a family has more points of resemblance than a couple to a joint stock company. But it should be remembered that any actual social system may admit a freeze on a problem to be another 'solution' and that it can preserve itself with inherent logical contradictions. Luhmann asserts that:

> Such a strictly logical or dialectical contradiction as 'A = not A' does not come under discussion. It makes any simultaneous solution of different problems impossible. However a proposition of functionalism suggests that any social system can continue to survive in spite of the existence of various contradictions.[8]

Now we must take account of another factor that governs the persistence of a social system. It may be called the environment or field. If we consider a social system instead of a system in general, we cannot treat it by itself (*an sich*), since it is inseparable from its environment, which can be another system or a set of different static structures. Luhmann contrived to combine a social system with its environment, and constructed the 'system/environment theory[9]'. If a system is considered from such a methodological perspective, its motion can be considered to be a persistent, self-sustaining one, which Norbert Wiener called homeostasis[10]. He referred to the concept mainly through the connection between the feedback principle and physiology, but did not argue generally for its relation to systems theory. In this regard Luhmann conducted a closer analysis. He commented that 'any organic body carries out a compensational, alternative, suppressive or complementary operation on environmental conditions and events in some effective form, and preserves its own structure.[11]' In other words, a system in general has a function of self-preservation that can maintain its resuscitative ability including adaptability to changing environments. This function may be called homeostasis in a strict sense. We classify several types of homeostasis according to the mode of social existence of human beings.

Mankind may be regarded as a social system and at the same time as an environment, since a 'social system is not composed of human beings themselves, but of their behaviors operated by mutual expectations[12]', while a collection of individuals forms a certain social system. In such dual circumstances three types of homeostasis can be identified:

(1) social homeostasis corresponding to the self-preservation of a social system,
(2) individual homeostasis corresponding to the self-preservation of man as a social being,
(3) unsociable homeostasis corresponding to the self-preservation of an 'isolated man' (*Einzelmensch*[13]).

An 'isolated man' is an unsociable individual, whereas an individual is a sociable 'isolated man'. And the term 'self-preservation' implies the autopoiesis of a system, which will be discussed later. Now if it is supposed that the split between (1) and (3) deepens and (2)

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[8] *Ibid*., S.114.
[9] *Ibid*., S.111.
[10] Wiener (1961), pp.114-115.
[11] Luhmann, *op.cit*., S.109.
[12] *Ibid*., S.118.
[13] This word was coined by Troeltsch (1922).

becomes impossible, the homeostasis of (2) shall deteriorate into that of (3). Then the social relationship between individuals and the structure of communication among them will be changed into ones between 'isolated men'. Consequently a new social field for communication may be prepared, where depersonalized and mechanical communication takes place exclusively. It includes legal, political, economic and social structures of an independent and separated character, which as a whole construct, as it were, a 'discrete society'. As society demonstrates a tendency to become a 'discrete society', individuals and 'isolated men' are prone to break away from any communication network or to bring about a state of discommunication. Nevertheless any 'discrete society' will secure its self-preservation by means of a sort of mechanical rationalization derived from the 'system rationality'. As Luhmann argues, 'a system of behavior exclusively contributes to system rationality in the capacity of the function of potential persistence of a function, and consequently does not become substitutable[14].

However, even if the concept of homeostasis is indispensable to the understanding of human society, it is impossible for us to reveal in it the full means of explaining social phenomena. Moreover, we should not be too hasty in ascribing a social catastrophe to the qualitative deterioration of homeostasis in a society. Perhaps we had better employ the term more restrictively with the same meaning as 'self-organity' in sociology. In the next section we adopt the term autopoiesis instead of homeostasis in order to consider various formal aspects of a social system from a slightly altered logical perspective.

III

Here we begin by formulating the concept of system in comparison to that of 'category' in mathematics, and then examine the notion of autopoiesis. Subsequently and lastly, we perform a systems analysis of several metaeconomic propositions.

If we consider the structure of a system as the 'input/output schema' (cf. Section Ⅰ), its most universal form of representation may be reduced to 'category' in a mathematical meaning. This interpretation must be examined in more detail. First, the correspondence between system and category can be illustrated as follows:

Input	→	Operator	→	Output
|		|		|
Domain		Morphism		Codomain

The operator may be regarded as a function or mapping, more generally as a morphism. If we regard both of domain and codomain as a collection of elements, and operator as the relationship among them, we can identify system with structure. However, system as a structure in motion exhibits two remarkable properties; first, the continuity that implies synchronic or reversible iteration, and second, the discontinuity that is represented by irreversible iteration or diachronic and irreversible process (history!). The simplest expression of the former is a closed mechanism mentioned below, and the latter may be exemplified by wars, revolutions and other various structural transformations in history.

[14] Luhmann, *op. cit*., S.123.

Secondly, operator in a mathematical sense has certain fundamental functions such as a morphism within a category, a 'functor' from one category to another or binary relations. Accordingly there appear many sorts of domain and codomain as input and output, and the preservation and transformation of input in relation to output is performed continuously in the form of quantitative extension, homomorphism, mechanism and connection with different operators. Furthermore, it should be noted that a fixed code is indispensable to an operator. It is a sequence of theoretical symbols that allow us to process (decode) pieces of information as input and to transmit messages as output. Usually there are several codes in a single operator. In other words, making a code is the important function of an operator, which may be called coding. When there are a couple of codes that are mutually inconsistent, a kind of insulator must be devised to separate them. The production of such an insulator is also a function of an operator.

Applying the above formal characterization of a system, we can examine an important concept in social systems theory. Luhmann named it *autopoiesis*. He defined it as 'the unification of reproduction of units[15]'. For example, in a system of behavior the motion of a cell or a macromolecule is not iterated, but behavior itself must be reproduced continuously. This is an essential feature of an autopoietic system (hereafter called AP system). Luhmann asserts:

> In the AP systems theory the highest priority is put on the question how we can make the closest approach to the events of elements. The kernel of the fundamental problematic may not be found in the iteration of elements, but in the connectivity of them.[16]

Therefore it is supposed that there is a certain temporal order among the elements of that system, while its characteristics are dependent on the position in the hierarchy where each element—for example, cell or behavior—ranks. The function of an operator in an AP system is two-fold in terms of category theory; first, that of morphism from domain to codomain, and second, that of morphism from one hierarchy or category to another. The latter is often named *functor*.

The most remarkable property of an AP system is that it is a closed self-reference system that 'allows each element of it to recur to itself through the medium of the other elements'.[17] But at the same time it is an 'open system', since 'it can reproduce itself only in a certain environment or a difference from it'.[18] From a formal point of view, Luhmann's concept of autopoiesis may be similar to that of a *clopen set* in mathematics. This analogy is deducible from topology rather than from set theory. In fact, a typical example of clopen set is a subset of a disconnected topological space. If F_1 and F_2 are supposed to be two subsets of a disconnected space (set) F, then the direct sum ($\oplus$) of them can equal F; $F=F_1 \oplus F_2$. Luhmann suggests that this composition of sets may represent the structure of society that is composed of AP systems and their environment. We examine further his discussions on an AP system below.

In relation to the notion of communication, he described society as an AP system as follows:

> Any society is an autopoietic system based on meaningful communications. It is composed

[15] Luhmann (1984), S.61.
[16] *Ibid*., S.62.
[17] *Ibid*., S.60.
[18] Luhmann (1988), S.49.

> of communication itself, of all possible communications. Everything that constantly arises in a society is necessarily reduced to the realization and reproduction of itself. Therefore, communication cannot exist in and with the environment of society. In this respect a communication system appears as a closed system. However the existence of any society exclusively depends on certain types of environment, especially on mental consciousness, organic life, physical phenomena and the evolution of the sun and atoms. Society can admit such a situation owing to its establishment as an open system. It performs communication *concerning certain objects*, that is, society itself, its environment and the theme of communication that is just being done. In effect, any society is a closed and open system, and communication is the fundamental form of operation that continuously reproduces such a dual property of social system.[19]

These arguments suggest that any society can be established as a communication system and at the same time as an autopoietic system when all of the messages with no *terminus ad quem* are necessarily combined to form a fixed communication. Since the completeness and sociability of a system creates its 'clopen' nature and these two properties can be acquired by communication, the structure of a society is to be reduced to that of communication.

Then it should be noted that in a closed system input and output have been built-in implicitly. This is the case in a closed mechanism. It is a ringed complex system where the output in a certain point of time coincides with the next input. Let's suppose that two systems make up a closed mechanism. Then the following diagram can be drawn;

Input	→	Operator	→	Output
॥				॥
Output	←	Operator	←	Input

It is clear that the entire system in the diagram is closed completely and that both input and output are embedded there or out of sight. The system itself appears to be inconsistent with the 'input/output schema', but its extended form as an open system can be totally preserved in the input-output relationship with an environment. Then how can it be actualized? From an abstract and static viewpoint it may be considered to be the result of a combination of two structures. However, the vital point is whether they can be combined. If a couple of systems can be combined together, one must be open and the other closed. When both of them are open or closed, the combination is almost impossible. Generally speaking, any open (closed) system can exist on the assumption that there is always a closed (open) system annexed to it which is contained in the environment. The combination of these two distinct and opposite systems may be called a 'connection'. Naturally they can be connected with each other on condition that any two of them alternately become open and closed. Using mathematical terms, we can express more clearly such a situation that the so-called 'connected space' is constructed among AP systems that include 'subsets' of environment. For example, an ordinary household system and the capitalist system can be connected with one another, since the former plays the part of a microscopic closed system and the latter that of a microscopic or macroscopic open system. This is a typical relationship between two distinct AP systems, but a peculiar characteristic of

[19] *Ibid*., S.50.

autopoiesis (self-reproduction) can be revealed in the time-pass of a single independent system.

In this case a reproducing (including replicating) process of a system can be represented by a sequence of infinite compositions of the category **1**, which is defined by S. MacLane as that with one object and one arrow which means endomorphism or automorphism[20]. Let an AP system be represented by a category **1** that is denoted as < ↻ > . Then we have the following successively reproducing or 'creating'(⇒) process;

↻⇒↻⇒↻⇒↻⇒ · · · · · · · · · · →direction of time.

The formal (algebraic) structure of this diagram can be expressed by an infinite semigroup of endomorphism whose element is the category **1**. We may call this 'element' an AP system! But, lastly, it should be noted that every autopoietic system always includes a temporally continuous element. It makes a temporally continuous sequence of clopen or disconnected sets, whose structure can be formally represented as that of a certain topological semigroup. In other words, it shows a continuous, but irreversible character of the metabolically finite lifetime of all creatures.

Upon these preliminary investigations we attempt a systems analysis of economic theories. In this respect Luhmann appropriately remarked as follows:

> In so far as various economic sciences are oriented toward the Science, they themselves become a part of a socially independent autopoietic system. Their basic operation is to reap the benefit of recognition. They produce recognition out of recognition, and qualify as recognition what can preserve this quality in a recursive relation to other recognitions.[21]

These 'economic sciences' can be regarded as an unstructured set of theoretical systems of economics that may be called collectively an *operator of economic theory* (abbreviated below as OET). Then we can observe the concrete structure of an autopoietic system on which the OET works.

Initially a group of 'theory-producers' or economists such as Quesnay, Marx, Leontief, Sraffa and others are inputted in a subsystem of the economic system. Their cogitation becomes a pillar of the system. They made the most use of 'metaphors' (Luhmann) to produce a theoretical system. The Quesnay's *Tableau économique*, the reproduction schema of Marx and Leontief's interindustry-relations table are the most representative theoretical systems or models of economic circulation. They form the category of groups, since their mathematical structure can be expressed by the concept of group.[22] However there can be another type of theoretical system with the metaphors of 'extended production' or 'growth', which can be mathematically represented by a certain type of semigroup. On this occasion it is considered that a certain 'functor' is operating within the OET. It may be called the 'accumulation functor', because it adds some elements of accumulation in an economic sense to the category of groups. The so-called 'regulation theory'[23] seems to have contributed to bringing up the same type of subject matter as the 'accumulation functor', although in a vague and somewhat biased way of description.

[20] See, MacLane(1998).

[21] *Ibid*., S.75.

[22] See, the discussions of Kamitake (2006).

[23] For example, see, Boyer (1986).

Then what is the output of OET? It may give rise to various types of ideology of economic policy. For example, we are reminded of some forms of capitalist nations' economic planning, theory of a socialist planned economy or the economic development theory of a developing country and so forth. In this respect it should be noted that these forms of ideology can modify a given economic reality and produce a different and virtual one that becomes a logical 'model' of economic theory. In other words, new kinds of economic cogitation are constructed on the basis of different 'models'. The meaning of 'model' can be defined by 'model theory' in mathematical logic. These 'models' are inputted into economic systems for the production of OET. As a result, a kind of self-referential—recursive and impredicative—construction will continuously emerge and a set of economic 'models' transform itself into an AP system that creates a 'neighborhood' or 'boundary' in the topology-like world of scientists.

IV

Next we must clarify how to establish a distinction and relation between machinery and system in connection with the existing conditions of human beings. There are two main problems. First, how can mankind become a main controller of various AP systems by opening and closing its black box? Second, how can mankind as an AP system control itself? These two problems are fully, but unsystematically treated below.

We start our discussion about the definition of human beings and machinery as controllable systems. From the viewpoint of a system a human being may be regarded as a sort of machine. But he must be something beyond machine, since he is supposed to have a unique ability that the latter does not possess. For this reason, the image of mankind has been constantly depicted as a meta-mechanical existence that surpasses machine itself, while only a few human beings continue to pursue the ideal of humanity for their own existence as such.

From a rather different angle we can also grasp the concept of human being. Under the situation that a mass of messages are constantly created and contingently connected with one another, it is increasingly difficult for us human beings to maintain our normal social existence and even social function as systems or machines. Nowadays, when the mass media as a source of information and the telecommunication-network as a means of social communication have constructed an enormous scale of information space, most people are obliged to accept a great bulk of arbitrary messages. We can ordinarily observe such human behaviors as watching television in the home to fill the time, operating a computer according to the given rules, and using a cellular phone or listening to music through earphones on a commuter train. From the viewpoint of a system what does this pattern of life stand for? Every laborer in the office catches and decodes external messages as input and receives a certain amount of wages as output, but does not run any operation for its own sake. He may be a fairly malformed system, since the range of his operation is mostly limited to the scale of his workshop. In other words, he cannot properly fulfill his function as a system in off-hours, and his freedom from work may often degenerate into lawlessness, debauchery or idleness. Although Marx generated the image of a laborer who was treated inhumanly in a wretched workshop and was addicted to drinking, going out for sex or gambling in off hours, his passionately animated narrative can be embellished in a more refined manner to explain moral decadence and the deterioration of human beings. However, no group or 'proletarian' class of deteriorated men and women can maintain a given social order, still less transform and revolutionize the framework of an existing society!

Next we must make formally a conceptual comparison between machinery and system. For that purpose we make use of the concept of a 'free machine' in which the word 'free' does not stand for 'liberty', but an 'uncontrolled' situation or a 'laissez- faire' state. If an ordinary human life is identified with a sort of machinery production, this human-machine may be considered as a waste-disposal plant. Such a change of our viewpoint allows us to confirm that an unintended input/output relationship prevails outside the original teleological structure of machinery. Thus a 'free-machine' can be defined as another machine that is dual to a given original machine.

Now it must be remembered that a concrete machine that carries out an actual productive operation has a formal structure of an algebraic semigroup, while an abstract machinery that is shown on the display of a computer has that of a group. Therefore, the latter can be regarded as a reversible system or closed mechanism. Then what is the difference between machinery and system as abstract and structural concepts? Certainly machinery is a kind of system, but system is not always equal to machinery. Only a controllable and static (not dynamic) system can be considered as machine. For example, the solar system is not a machine, since it cannot be controlled by human power. Any machinery system must be regulated by direct or indirect efforts of mankind. Accordingly a nuclear weapon is a machine, since it is manufactured through the technology of controlling a microscopic system of particles for the purpose of mass murder. Thus the following equations can be derived:

machinery=system+controllability−dynamism, or
machine+'free machine'=system−the property of dynamic equilibrium

As to a 'free machine' a few examples show its characteristics. First, any production facilities may be a set of machines insofar as they reflect the intention of a controller (mankind). But when they go beyond human control they are likely to be integrated to form a 'waste-making operator' that increases environmental pollution. Within a given total system this independent 'free machine' produces the accumulation of output that may destroy the existing social and natural systems appropriate to human life. Another kind of 'free machine' can be operated with a certain type of socially malicious intent. A typical example is the computer virus. It paralyses a computer system by means of its operator, and consequently carries on a secret operation that is opposite to the negative feedback about a self-sustained control system. The same type of 'free machine' can be found in a lawful action that may damage a legal system, as many judicial precedents of criminal offense suggest. Such a legal action often denies the original social intention in a positive legal system, and then damages the common feeling of confidence in the system itself. The rule of democracy as a social system may also bring about a functional shift of itself toward that of the game for majority. These examples of 'free machine' represent the self-negation or negative self-reference of a certain type of social system. Notably, any scan-operator of a 'virus' (in fact, malicious persons) is not originally installed in such a system. Rather it may be said that the system as a 'free-machine' can continue to reproduce a combination of a 'virus', an operator of defense against it and a more harmful 'resistant virus'.

On the basis of these concrete examples of 'free machine' one can consider another aspect of social systems theory. There can be an internal factor (called a 'self-denial factor') that negates a certain system through its own operator. Just as there is a proposition that is established by an operator within a given logical system and that can be neither denied nor affirmed by any logically possible operations, there always exists a 'self-denial factor' that can exert a destructive power over the entire self-referential system. Whenever such a 'factor' emerges in a social system, it is often scanned and eliminated in the form of 'restructuring', rationalization or purging. If it spreads far and wide, social unrest may be caused and sometimes a spontaneous social revolution occurs. On the contrary, another 'factor' may react against a revolutionized social system and cause a counterrevolution. However, it is also possible that an increase in the number of 'self-denial factors' does not bring about any dynamic change in the social system. This is a case where a given social system has a tendency toward *corporationalizing* or a Sisyphean self-reproduction. The 'self-denial factor' that makes its appearance there does not play a positive, deliberately destructive role, but serves the negative function of system-preservation and cover-up of contradictions. It may cause a serious feeling of entrapment among people within the system. In other words, its original teleological structure will be broken down and the self-preservation of the system itself becomes its own end.

Now we call into question how human nature emerges and operates in our mechanized society. A human being can be regarded as a universal machine and therefore as a being that has reason of various sorts. Technologically reasoning human power may be called imagination. When we consider any object of our thinking as a structure or structural concept, we can define imagination as the integrating ability to set up a new structure of given structures, or as the continuously connecting ability in an autopoietic system. In a more intellectual sense it can also be called *recognizability* with which man can recognize machinery as an external object and operate it as a toy for children. Thus imagination or recognizability becomes the key indicator of distinction between mankind and machinery. It allows men to achieve self-insight and self-realization.

However, the evolution of mankind must be accompanied by its devolution as its counterpart. It may be shown most remarkably in the historical process of industrial revolutions. It seems that mankind has wasted its original recognizability and at last becomes a special-purpose machine in that process. The exclusively mechanized nature of human beings has been revealed in such persons as a civil servant who offers a stereotyped solution according to guidelines to his office (a law), a narrow-minded expert who thinks only of his extremely specialist field of study, and a conservative business person who follows a regular routine and is not able to make any innovations. Perhaps we cannot reveal any means to prevent the deterioration of recognizability, since a majority of our society will be increasingly formed by unimaginative persons who function as special-purpose machines and at the same time the appearance of men of great recognizability will tend to be a rare and accidental social phenomenon. The latter type of mankind can only exist as a member of a social minority and consequently may be destined to disappear into the twilight of the humanistic world.

Lastly we must refer to a 'free-man' in contrast with a 'free-machine'. A 'free-man' is closely connected with the structure of play. There seem to be three distinct sorts of play. The first is an act of enjoying oneself that is opposed to serious work. The second represents freedom of mental and physical activities. For example, thinking scientifically from a 'value-free' standpoint means engaging in science as a play activity. The third type of play is a game or social activity (*Gesellschaftsspiel*). If scientific activity is defined as an application of rules (theories) to the object of research according to the requirements of a certain paradigm, science can be regarded as a game[24]. Especially pure science—for example, mathematics or theoretical physics—can be a pure game, since it has no impure elements such as a pay-off function in game theory. Here lies the difference between a game as play itself and an impure game. The latter is under such external constraints on its players as the maximization of profit and/or the minimization of loss. These conditions enabled von Neumann to formalize a game mathematically and to give it a teleological economic structure.[25] As a result he created the strictly logical and therefore abstract concept of game. Thus an impure game has become an abstract mathematical object that allows most economic theoreticians to play another kind of game. It may be called *a game of game*, which means an academic competition for a new model of economic game theory.

Generally speaking, play in a wide sense is a means by which everyone as a subject of recognition can be conscious of oneself within the sphere of one's own recognizability. The term *homo ludens* that Johan Huizinga used in his famous book of the same title may reflect such a view of human beings.[26] Since any play has the same structure as a 'free-machine' or non-machine system, it may be considered as a system itself. Its operator is a rule of play or, more restrictively, a rule of game, and its input and output include both man and nature. As the play-system is increasingly mechanized, it will become an impure and abstract game that can be played by machines or robots.

V

Finally we suggest a provisional and hypothetical schema concerning the relationship between various economic systems of autopoietic character and the world capitalist system.

The simplest of these systems is originally that of an 'economic man' or an entrepreneur of European type, who was an educated, liberal and independent man of culture under the influence of stoic Protestantism or Puritanism. Then, especially in the latter half of the 20th century, the 'economic man' became an 'economic animal' under the regime of Asiatic and ochlocratic groupism or 'capitalist totalitarianism'. The fittest type of capitalist operates an AP system, and the most elementary key factor for providing various economic and economically oriented organizations that also operate as autopoietic systems. These are themselves dynamic allopoietic systems and construct a set of clopen sets that are directed and oriented by the worldwide capitalist system. However, we must bear in mind that this global system is a bordered physical object called the Earth, and therefore it is a finite, closed system. Naturally it builds an absolute barrier to all movements of economic and non-economic AP systems.

Is there any way for an individual AP system to survive such a situation? Perhaps not. Rather the worldwide transition from mutually exclusive, rigid AP systems to 'autolysic' or 'apoptosic' systems may occur with surprising speed, and at the same time increase the 'social entropy' to the utmost limit. Moreover, as the number of 'economic animals' increases everywhere on the Earth, a human being will become a 'human animal' who, as a monstrous AP system, lives only for the life of optimizing the satisfaction of his or her brutal desires for

[24] See, Nolfi (1969).
[25] See, von Neumann (1928).
[26] See, Huizinga (1938).

physical and mental objects.

References

Boyer, R. (1986), *La Théorie de la Régulation*, Paris, La Découverte.

Bühl, W.L. (1975), 'Elinleiting : Funktionalismus und Strukturalismus', in Bühl, W.L., *Funktion und Struktur : Soziologie vor der Geschichte*, Munchen, Nymphenburger Verlagshandlung.

Huizinga, J. (1938), *Homo ludens*, London, Routledge and Kegan Paul, 1980.

Kamitake, Y. (2006), 'The Formal Structure of Metamorphosis of Capital', in *Hitotsubashi Journal of Economics*, Vol.47, No.1, Tokyo, Japan.

Luhmann, N. (1975), 'Funktionale Methode und Systemtheorie', in Bühl, W.L., *Funktion und Struktur : Soziologie vor der Geschichte*, München, Nymphenburger Verlagshandlung.

Luhmann, N. (1984), *Soziale Systeme*, Frankfurt am Main, Suhrkamp.

Luhmann, N. (1988), *Die Wirtschaft der Gesellschaft*, Frankfurt am Main, Suhrkamp.

MacLane, S. (1998), *Categories for the Working Mathematician*, 2nd ed., Springer-Verlag.

Neumann, J. von.(1928), 'Zur Theorie der Gesellschaftsspiele', in *Mathematische Annalen*, Bd. 100, Berlin, Springer.

Nolfi, P. (1969), 'Strategische Spiele', in *Dialectica*, Vol.23, Neuchatel, Switzerland, Editions du Griffon.

Piaget, J. (1968), *Le structuralisme*, Paris, Presses universitaires de France.

Troeltsch, E. (1922), *Der Historismus und seine Überwindung*, Berlin, Rolf Heise.

Wiener, W. (1961), *Cybernetics: or Control and Communication in the Animal and the Machine*, 2nd. ed., The M.I.T. Press.