A System to Quantify and Decrease the Disturbance Effects Generated by Chaos Factors in Economy

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Abstract

In this paper is proposed a system to quantify and decrease the effects generated by the chaos factors. To build such a system implies the establishment of some stages, that must be followed very strictly. Each stage is based on some principles, which conduct to the decreasing of risk factors.

The authors proposes a lot of principles which allows the building of some scripts that have as objective functions the decreasing of the disturbance's effects generated by the chaos factors.

In the paper it is proposed schematic system for quantify and decrease the risk generated by the chaos factors. This system is a multilevel, hierarchical and learning system, in which the commands and adjustments signals are transmitted not continuos but at some periods of times determined by the nature of the system. The system allows the evidence of adjustments loops at each hierarchical level and between the levels.

Keywords: chaos, principles, classification of factors, perverse effects, decreasing quantifying system.

I. Introduction

The complexity of economic systems in the present stages of objective and subjective interconditioning between them demand an analysis of the phenomena that govern them, with the goals of more efficient leadership and of avoiding the factors that could generate chaos. With these goals in mind, it is necessary to specify:

* the stages of analysis for the chaotic processes that act in an economy;
* the classification of the factors that generate chaos;
* the principles that will lead to the decrease of these chaos factors;
* the construction of a cybernetic system that will quantify and diminish the chaos-generating effects in an economy.

II. The Stages of Analysis for the Chaotic Processes that Act in an Economy

In order to construct a system that will analyze and diminish the disturbances generated by chaos factors, it is necessary to specify the main stages of the construction process.

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In the third and fourth Chapters, stages II and III will be detailed. Stages IV and V are related to the creation of a model and the determination of the performance indicators for this model (conceptual, descriptive, normative, procedural) that form the basis of the scenarios. Applying each type of model will depend on the type of system to be analyzed, and on the available information.

Conceptual and descriptive models are to be used on badly defined and structured problems with insufficient information. They can yield a solution directly, or form a basis for normative and procedural models.

Procedural models and the scenarios based on them are to be used where the main role is given to the algorithm, and a secondary role to the model. They are used for complex situations where the economic realities are lost if they are described through a largely normative model.

The standards of performance are determined by the type of the model that the scenarios are based on, and also by the quality and accuracy expected of the solution.

If the error in the prediction of performance goes beyond certain pre-determined limits, it will be necessary to restart stages I, II, III, IV or V, depending on how serious the error was.

It will be necessary to exercise permanent and continuous control over the effects of the applied scenarios to diminish the chaos factors, and this can be achieved by creating a hierarchic cybernetic system with multiple correction loops, which will be described in Chapter V.

III. The Classification of the Factors that Generate Chaos

To be able to take measures that will diminish the effects of chaos-generating factors, it is necessary to classify them. For each class of such factors, specific methods of diagnosis, diminishing and prevention of chaos can be developed. The authors propose the following classification:

1) The class of factors issued from major contradictions;
2) The class of factors related to acknowledgment and information about the system;
3) The class of factors related to the structure and organization of the system;
4) The class of factors related to the dynamics of the system's elements;
5) The class of factors that characterize the relationship between the system's elements;
6) The class of factors that lead to the fulfillment of the system's objectives;
7) The class of factors related to the control function of the system.

1) The class of factors issued from major contradictions refers to those factors that take a system from a *stable* status, a status of *equilibrium*, to one of *desequilibrium*, to an *unstable* status, a situation which, unless the necessary measures are taken, can lead to the annihilation of the system itself. Any system contains a certain *state of entropy* that opposes the achievement of goals and that can lead to *instability* unless it is controlled. There is a connection between the entropy of a system and its degree of organization. The degree of organization is defined as the ratio between the entropy of the perfectly organized system and that of the real system:

$$g_{oh} = h(S_0) / h(S) \qquad (1)$$

One must keep in mind that a system can be represented as a union of sub-systems, so the global entropy is the sum of the entropies of the sub-systems:

$$S = \bigcup_{i=1}^{n} S_i \qquad (2)$$

$$h(S) = h(\bigcup_{i=1}^{n} S_i) = \sum_{i=1}^{n} h(S_i) \qquad (3)$$

Likewise, there is an entropy of connection between the sub-systems and the entropy of the system as a whole, so:

$$h(S) = \sum_{i=1}^{n} [h(S_i) + h(S / S_i)] \qquad (4)$$

One way to reduce the entropy of the global system is to reduce the entropy of connection. For instance, for a system of production the reduction of the entropy of connection can be achieved through a flux system of the production.

In a system of stock (of merchandise), the entropy of connection can be reduced by introducing a computerized system for keeping inventory, and a network of computers that will inform each sub-system of changes.

Another way to reduce the entropy of the system is to reduce the entropy of the individual sub-systems through their better organization. So, one can see that the factors related to *order* and *disorder*, *equilibrium* and *desequilibrium*, represent important groups in the class of factors issued from major contradictions.

For a system to perform optimally, it must be in a certain *state of equilibrium*. Both the entropy of the system and technical progress tend to disturb this equilibrium. If entropy has a negative effect on the state of equilibrium, technical progress take the system from one state of equilibrium to another, even if there is a period of desequilibrium between these two stages. This period is related to the time it takes to introduce the new technology, which occurs as a result of the demand and competition within the market. One can see that it is important to identify the factors of *equilibrium* and *desequilibrium* for the duration of a system's life cycle. Taking a system from one state of equilibrium to another is another inherent factor. It is necessary to achieve a reduction of the desequilibrium factors as long as the cost of doing so isn't greater than that of finding new points of equilibrium (a re-organization of the system through the introduction of technical progress). During *the transition period* of a system from one state of equilibrium to another, *constructive* and *destructive* factors also act.

Constructive factors are related to the introduction of the new system's structure, destructive factors to the removal of the old structures. Destructive factors act also as a consequence of the physical and moral deterioration of the existing system, or as a consequence of a strong disturbance within the system. In the latter case, the decision-makers within the system must pursue a policy that will act against its effects. Planning this policy depends on the predictable or *unpredictable* character of these *disturbances*. It is necessary to quantify these predictable and unpredictable factors that act upon a system and that have implication in the planning of the command and control (decision) factors.

Depending on the above, it is necessary to introduce a *prediction system* for the evaluation of such disturbances. The *time span* of these predictions, as well as the *moments in time* when data are collected must also be specified. It is important to take into account both the factors that cause a major disturbance, as well as those that cause minor negative effects that accumulate and grow with time. Knowing these factors is important for the choice and implementation of the best methods that would diminish negative effects.

2) The class of factors related to acknowledgment and information about the system is divided in the following groups:

a) Factors of error in the collection of data. These are due to the collection of data in points that don't have minimum entropy, due to faults in reporting information, or to the passing on of false information. It is necessary to determine the points of data collection where entropy is lowest, as well as the moments in time when data is to be collected in order for the data to be representative. Also, there must be filters that separate *significant* from *insignificant* data.

b) The group of factors related to the depth to which the system is known. These factors can lead to incorrect planning which in turn can generate chaos. The degree of detail to which a system is known depends on the objectives, on the material and financial resources available, on the nature of the system, and on its structure. There are techniques of investigation (interviews, surveys, journals), techniques of direct observation or observation of prototypes that simulate parts of the analyzed system, which together can contribute to the reduction of the chaos effects generated by the level of knowledge.

c) The group of factors related to misinformation or deliberate intoxication and infection with viruses of the informational system. These are other elements that generate chaos. In order to avoid the development of similar systems with superior a performance by competitors, often the managers of a system will intoxicate or virus the competition's system.

The ripple effect caused by the deliberate introduction of false data plays an important role in causing chaos in a system. The time of propagation and the intensity of the phenomenon influence the speed of installation and the proportions the chaos will take.

That is why authentic and false information must be separated, and security systems must be implemented to protect the data base from the spread of such information.

Complex systems yield immense amounts of data which need to be processed in order to find viable models whose solutions can be found in polynomial times. The processing function must be *non-catastrophic*, *sensitive* and *non-compensatory*. Sensitivity implies that small variations in the input result in similar variations of the output. A non-catastrophic function is one where provisions are made so that large variations in the input don't result in variations of the output beyond certain limits. The non-compensatory character of a system implies that the increase of a certain argument doesn't compensate the decrease of another. For instance, the amount of domestic sales doesn't compensate for a poor performance in exports.

The *fussyfication of information* can lead to the loss of information because not all levels of this data was taken into confirmation. *It is necessary to quantify this factor, evaluate it analytically, and defussyfy the data.*

3) The class of factors related to organization and structure

To understand the structure of a system one can observe the system in the action, or, if one knows its input and output values, one can simulate it. To understand the structure and organization of a system, it is necessary to decompose it by hierarchic level and decide on the attributes and functions of each level. The planning of the decision-making system and its organization require the detailed understanding of its structure and objectives. It is necessary to specify the *compatibilities* and *contradictions* of the system, and to harmonize the structure, organization and functionality of the local sub-systems in relation to the global system that contains them. Thus, the notions of *specialization* and *coordination* appear.

Distributed, decentralized systems ensure a lessening of those chaos effects caused by *incompatibility*, *contradictions*, and *lack of harmony between the sub-systems and the whole*. One way to coordinate them is through legislation, norms and rules governing the functioning of the system. A very *rigid coordination* can lead to an exaggerated amount of planning and the lack of an adequate policy with regard to the *unpredictable factors* that act at a low level. Lack of coordination, on the other hand, can lead to the *chaotic functioning* of the sub-system within the global system. A middle path between these two extremes is best, and it can be implemented by a *participating management*. The existence of a participating management implies the reception of reaction information from the lower sub-systems by the coordinating sub-system, which adjusts its coordinating policies based on this information.

4) The class of factors related to the dynamics of the system's elements comprises the following groups:

- The group of factors related to the blocking of a system;
- The group of factors related to the dissipation and concentration of the elements of a system;

- The group of factors related to rhythmicity and the frequency with which elements of the system moves;
- The group of factors related to the guiding of these movements, or lack thereof;
- The group of factors related to the homogenization or segregation of elements within the system.

For a system to be dynamic is essential to its existence and development. The sense of its movements illustrates the rise or fall of the chaos elements within, effects generated by the degree of correlation between the factors of movement.

Thus, different speeds in the circulation of capital can lead to partial blocking, which over time can increase the effects that lead to chaos (through a disorganization of the elements with a higher circulation of capital as well).

The disparity between the elements of a system over a large area can lead to a slowing down which, unless checked by timely measures of coordination, can also lead to chaos. On the other hand, greater concentration, though it allows better coordination, can lead to a decrease in the area of movement, a greater time of reaction, etc., factors that ultimately contribute to greater disorder.

The existence of unrhythmic movement over certain admissible limits between interdependent components can lead to a growth in stock and inventory, waiting too long for entry, delayed issue (beyond the due date), etc. These disfunctionalities have consequences for the global system and can generate chaos if it goes beyond certain limits.

The movement of system's elements must be guided in the direction of its objectives. If mistakes are made in this guidance, they can lead to an accumulation of negative effects that will endanger the very existence of the system. For instance, the development of a system that produces goods without correctly studying the market's demand for those goods will lead to an accumulation of unvendable inventory, financial blocking and even bankruptcy.

Factors of *homogenization* or *segregation* regarding the movement of the system's elements must be evaluated correctly, for putting too much emphasis on them can explain the formation of chaos-generating poles. The development of certain economic areas to the prejudice of others (segregation) or too strict a specialization can cause undesirable effects over time (the migration of the work force, an older population, social tensions, etc.).

5) The class of factors that characterize the relationship between the system's elements

This class is concerned with the relationship between the sub-systems as well as the relationship of the whole system with its medium. The nature of this relationship must be taken into consideration, for it can be material, human, financial, and temporal. It can play an important role when interfaces are conceived. If these relationships are in concert with the general goals of the system, then each sub-system and the system as a whole can function optimally. Any discord between the elements of a system implies the emergence of chaos elements. A climate of insecurity, rivalry between the executive personnel, miscommunication between the various sub-systems due to mistaken evaluations can lead to major disruptions in the system.

For instance, in a system of production, an erroneous evaluation of the relationship between the service and repair, sales, supply, marketing, and accounting sub-systems can cause stagnation.

It is interesting to examine the influence of the time factor on the prediction of development of existing relationships, on the appearance of new ones, or the disappearance of old ones.

The development or stagnation of such relationships is also caused by *competitivity* factors. To meet competition, cooperation or even mergers between systems can be effected. Sometimes, small firms that stay away from cooperation risk to go into chaos (go bankrupt).

6) The class of factors that lead to the fulfillment of the system's objectives

One group of factors that contribute to the fulfillment of the system's objectives is that of factors related to the decomposition of the system into sub-systems and the specification of each sub-system's function and objectives.

Apparently, there can be disagreement over the objectives of two local sub-systems, but agreement over the global objective. There must be *agreement* between the objectives of the several sub-systems and that of the global system. The factors that can generate chaos related to objectives are:

- Failure to specify and correctly execute the functions of each objective;
- Failure to coordinate between local and global objectives;
- Lack of communication between apparently unrelated objectives;
- Lack of harmony between objectives in the given time;
- Incorrect direction during the analysis or modeling phase;
- Inconsistencies between the planning-implementing phase and the analysis-modeling phase;
- Failure of the system's structure to adapt to the various disturbances that directly affect the objectives;
- An exaggerated increase in the number and scope of the objectives;
- Unwise or preferential emphasis placed on certain objectives;
- The existence of subjective factors introduced by decision-makers in the quantification of objectives.

7) The class of factors related to the control function of the system

A control method based on FORWARD and FEEDBACK regulation loops is necessary for a system to function between the specified parameters. Its faulty functioning or inexistence can lead to chaos. To diminish the chaos effects it is necessary to realize the limits to which the system can stray before an intervention takes place. A few chaos effects that can result from faulty control will be enumerated:

1. The loss of control over a time period of several components of the system, due to incorrect provisions;
2. The incorrect determination of the number of control points;
3. The incorrect direction of the control apparatus:
   a. Deliberate factors:
      - Lack of discipline;
      - Corruption;
   b. Non-deliberate factors:
      - Inadequate professional or technological training;
      - Inconsistencies between the existing disturbances and their measurement;
      - Failure to take into consideration morale deterioration;
      - Failure to take into account the boomerang effect through the control of certain parameters that don't belong to the system proper, but have a great influence on it (for instance, controlling pollution).

IV. The Principles that Will Lead to the Decrease of Chaos Factors

These principles are based on heuristic concepts. Apparently, they contain some contradictions or paradoxical aspects, and are expressed with a degree of vagueness. They must impress on the manager a new way of thinking that will allow him to *adapt* the strategies of the firm more promptly to new disturbances, thus diminishing the factors that cause chaos. They also allow the manager to acquire the "art" of decision-making based on heuristics, in both operative and strategic situations. The authors propose the following principles:

1. The principle of constantly observing the medium;
2. The principle of creating an artificial medium;
3. The principle of comparing, ordering and classifying natural, artificial or fictional elements;
4. The principle of antithesis;
5. The naturalist principle;
6. The constructivist principle;
7. The principle of using boomerang and synergetic effects;
8. The principle of turning a disadvantage to an advantage.

1. The principle of constantly observing the medium has as its purposes understanding the laws that govern the medium and making correct predictions. Observations are to be made both on a natural medium and on an artificial one.
The degree of intervention on the medium, g_{int}, is defined as follows:

$$g_{\text{int}} = \frac{Mes[E'_p]}{Mes[E_{ob}]} \tag{5}$$

where E'_p is the measure of events caused by man and E_{ob} is the measure of the field of events observed.

Depending on the value of g_{int}, there are methods of random observation (g_{int} = 0) or directed observation (g_{int} = 1) to capture the vision introduced by the human operators themselves in the process of observation.

Such methods allow the deduction of rules that managers can use to act on a medium in order to achieve the system's objectives (implicitly to reduce the effects of chaos on a medium).

The degree of disorder of a system can be defined as follows:

$$g_{des} = 1 - \frac{Mes[E'_p]}{Mes[E_{ob}]} \tag{6}$$

where E'_p is the measure of programmed events and E_{ob} is the measure of events observed.

The smaller gdes, the more complete the order in the system and the more prepared the system to deal with chaos-generating factors.

2. The principle of creating an artificial medium

Artificial prototypes can be created to simulate complex systems, or parts of systems whose status and mode of functioning isn't understood. Mathematical methods and simulations can be used both at the macro- and the micro-level. If the distance between the artificial and the real medium is small, the error of prediction is minimal.

3. The principle of comparing, ordering and classifying natural, artificial or fictional elements

This principle is used for the creation of logical relations of discernability, similarity and complete order that will allow the diminishing of chaos factors.

4. The principle of antithesis (or inversion) prescribes the application of decision rules through negation, to better estimate the chaos effects that are provoked, and to evaluate correctly the minimal allowed deviation (the allowed amplitude). The applying this principle one can discover new laws (that appear in crisis situations) and measure the efficiency of certain strategies.

5. The naturalist principle mandates that both natural and artificial systems function based on their own laws and those of the mediums in which they are. In this case, chaotic factors act positively, facilitating the development of competition which in turn leads to the demise of unprofitable systems. In certain cases, limited protectionism can be used to shelter those systems that have a special character and major importance (such as social protection programs).

6. The constructivist principle must be applied depending on the nature of the specific system to be analyzed. Constructivism is meant as the building of a leadership strategy that gives predictions an exaggerated weight in the decision process. If applied incorrectly to certain systems, it can lead to blocking, to totalitarian economic systems, and thus to an increase of chaos. For special systems, like those of security and defense, there can be favorable consequences. A protectionist intervention can have good consequences for new branches that are developed on the long term (for instance: nuclear energy, space research, etc.).

7. The principle of using boomerang and synergetic effects

The incorrect application of the synergetic principle leads to dissipation, and thus to an increase of chaos. By correctly connecting the factors that contribute to the synergetic effect, the positive effects of the system's functions can be amplified, thus reducing the chaos factors. An example would be creating a factory whose production complements those of already existing factories.

The boomerang effect is a product of the interaction between systems, as a reverse consequence of the application of a policy by one system on another, whether the policy was intended to be positive or negative.

For instance, incorrect behavior in the relationship between partners, in the sense of causing damage, can have repercussions on the one that initiated the behavior. The boomerang effect can have positive consequences if business partners are conscious that they belong to one super-system (like the European economic cooperation).

8. The principle of turning a disadvantage to an advantage can diminish chaos. An example is the loss of a sector of the market by an economic agent. This can determine a re-technologization that will eventually allow the domination of greater markets than the one lost.

This principle apparently contains paradoxes.

If boomerang effects were predicted to act positively but, due to chaotic factors, they take a negative turn, one can say they had *perverse effects*. An example: Repeatedly awarding bonuses to stimulate productivity can ultimately lead to a lessening of productivity due to the lesser motivation of those who carry out this process. Perverse effects can be prevented by building scenarios and simulations.

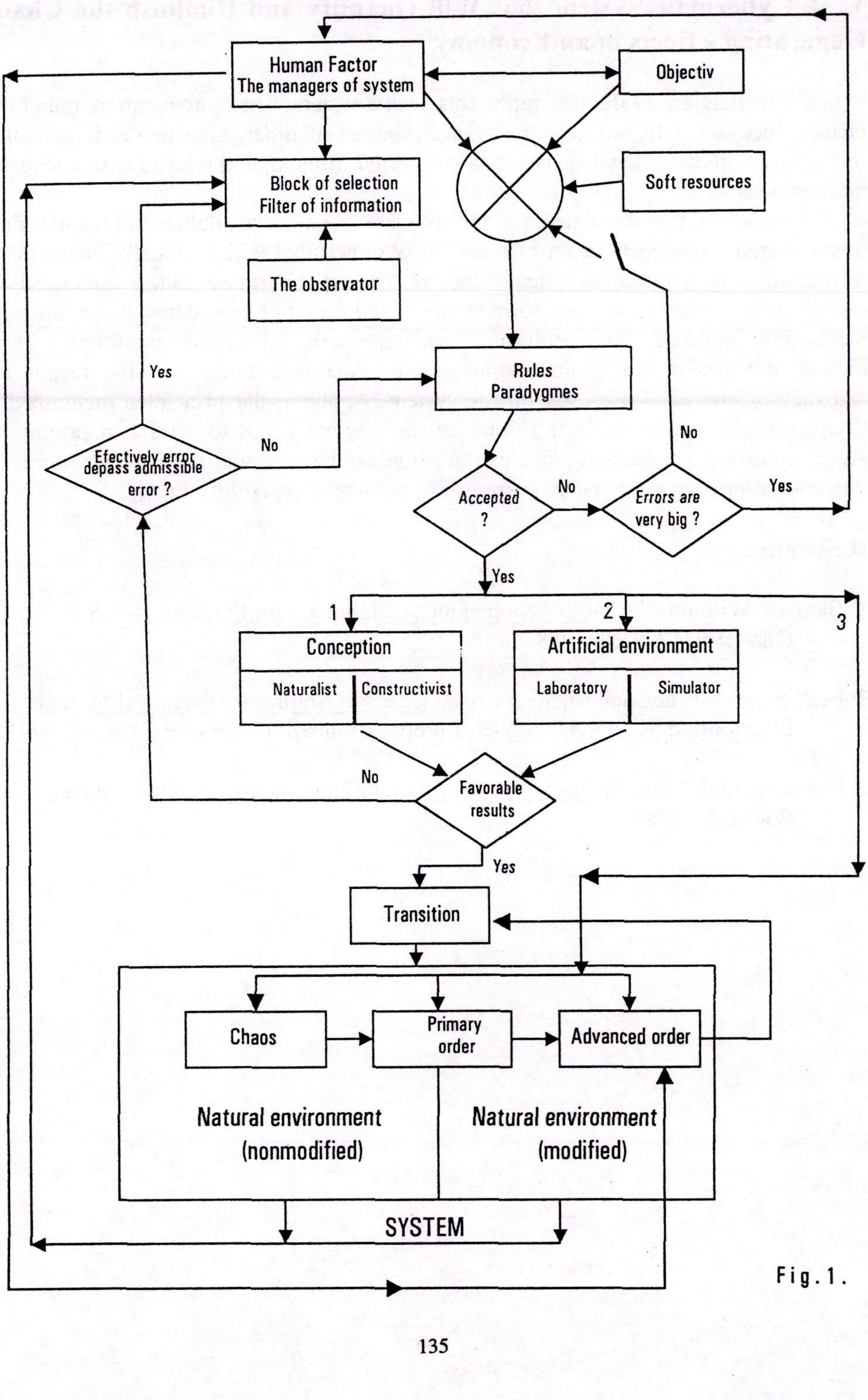
Human Factor
The managers of system
Objectiv
Block of selection
Filter of information
Soft resources
The observator
Rules
Paradygmes
Yes
No
Efectively error depass admissible error ?
No
Accepted ?
No
Errors are very big ?
Yes
Yes
1
2
3
Conception
Naturalist
Constructivist
Artificial environment
Laboratory
Simulator
No
Favorable results
Yes
Transition
Chaos
Primary order
Advanced order
Natural environment (nonmodified)
Natural environment (modified)
SYSTEM

Fig.1.

V. A Cybernetic System that Will Quantify and Diminish the Chaos-Generating Effects in an Economy

The diagram in figure 1 represents such a system. The system can be found in a chaotic medium with primary or advanced degree of order. One proceeds to collect information on these systems. The data is selected, filtered, and relayed to the decision-making body.

Depending on the objectives, the software resources available, and the decisions of the system's managers, a set of rules is elaborated that will eventually diminish the disturbances generated by chaos factors. Based on these rules, naturalist or constructivist conceptions are formed or, if the situation mandates it, an artificial medium is simulated. If the results are unsatisfactory the rules can be modified or, if the degree of error is too great, another set of data is collected. If the results are satisfactory, the rules are used on the system. Applying the principles mentioned in Chapter IV, as a rule one acts to change the original chaos to a state of primary or advanced order. The direction of this transition can be reversed if *technical progress is introduced*, or *if another system is created to replace the existing system.*

References

1. Baumol, William J., Chaos Phenomenon: A Nightmare for Forecasters, L.S.E. Quarterly, 1 March, 1988.

2. Feichtinger, Gustav, and Michael Kopel, Chaos in Nonlinear Dynamical Systems Exemplified by an R&D Model, European Journal of Operation, vol. 68, 1993.

3. Purica, I., Ordo ab Chao Order. Structures in Physics and Society, Ed. Tehnica, Bucharest, 1996.