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Research on the safety economic management system based on the dissipative structure theory

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Abstract

Dissipative structure theory was applied to safety economic management system. Demonstrated the dissipative structure property of this system, and the analysis showed that the system was open and farm from equilibrium state, there's a complex nonlinear relation among the internal elements and subsystems, and external and internal fluctuation significantly impacted the system's stability. Analyzed the circle of safety economic benefit with the application of the theory of dissipative structure, described its operating mechanism, and put forward thinking of leading safety economic management system to develop from disorder to order, that was, maintaining the opening of the system and fully using the fluctuations.

Keywords: safety economic management system; safety economic benefit; dissipative structure; fluctuations

1. Introduction

With the development of social economy and science and technology, the productivity increase substantially and people's gain growing, at the same time, man-made or natural accidents and disasters give a serious challenge to human's production, life and survival. Facing the huge accidental economic loss and the large number of safety investment, we have the responsibility and obligation to study and explore theories and methods of safety economy, and use it to guide the safety production, and to help the country, society and enterprises to get the greatest degree of safety in production in the limited safety investment conditions. This article will attempt to use the dissipative structure theory to analyze the safety economic system in order to deepen understanding of the operation mechanism of safety economic system, and to provide some theoretical guidance for the enterprise safety economic management.

2. Dissipative structure theory

Belgian scientists I. Prigogine founded the dissipative structure theory in 1960s. Since it's founded, this theory has showed tremendous vitality, it has achieved great development nowadays, and has formed a relatively complete theoretical system, and has become an important theory branch of the modern science system[1].

The dissipative structure theory is a science that research the nature, formation stability and evolution of the dissipative structure, is a theory about self-organization of the non-equilibrium system. This theory considers that when an open system far from equilibrium state, no matter mechanical, physical, chemical or biological systems, reach the nonlinear area, and changes in external conditions reach a certain threshold, it can change into ordered state of the time, space, or functional

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from the disordered state, by means of exchange of matter and energy with the outside world. And non-equilibrium, stable, ordered structure of this sort called dissipative structure. Entropy change is one of the important ideas of the theory[2].

To form dissipative structure, the system must meet the following four conditions: First, the system must be open, that is the basic conditions for the formation and development of dissipative structure; Second, the system must exist fluctuations, which is the incentive of driving system jump into the dissipative structure branch; Third, nonlinear interaction mechanism must be exist within the system, which is the inherent power for the system evolving from disorderly to orderly; Fourth, the system is far from equilibrium state. Prigogine pointed out that non-equilibrium is the origin of order, which means that if a system could evolve from disorder to order, it must be far from equilibrium state[3-4].

3. Analysis of the dissipative structure property of the safety economic management system

According to the characteristics of the dissipative structure, safety economic management system is accord with the requirements of the dissipative structure.

(1) The safety economic management system is an open system, it exchange human, material, financial and information with the environment in which it exists. Safety investment and safety output are important contents of safety economic management system, and this input-output process is the exchange of material and energy with the outside world. In addition, each subsystem of this system would be subject to system environment factors which contain nature, society, politics, culture, economic technology, national policies, laws and regulations, and resources.

(2) This system is far from equilibrium state. The characteristics of equilibrium state contain disorder, large entropy valve, and ultimate confusion degree, however, to maintain the normal order of production, enterprises must create a safe operating environment by the way of necessary safety investment, therefore, safety economic management system could keep order in time, space and function, and the system is far from equilibrium state.

(3) The structure among internal elements and subsystems of this system are nonlinear, and complex nonlinear relationship exist between safety investment and safety output, and safety investment and safety outputs are non-uniform among different enterprises or different departments of the same enterprise. Certain degree of safety investment must produce some Safety economic benefits, in a sense, safety investment is proportional to safety outputs, however, this input - output relations is complex and nonlinear in quantitative aspect. Interaction and mutual feedback among the major internal factors of this system exhibit nonlinear relationship. This relationship could improve or slow down the interaction among various factors, but the comprehensive effect is certainly not equal to the algebraic sum of action of each part.

(4)This system generates a random fluctuation, constantly subject to outside influences such as the occurrence of accidents, the adjustments of relevant policy, etc. When the fluctuation reaches a certain level, it will promote mutations in the system, and makes the system evolutes from disorder to order.

In a word, safety economic management system exchange material, energy and information with the external environment, and maintain a structure of input - output, the system is open, far from equilibrium state , nonlinear interaction among the internal elements and subsystems of the system, thus, we can analysis the orderliness of the system by using the dissipative structure theory.

4. Analysis of safety economic management system based on the theory of dissipative structure

4.1. Analysis of safety economic benefit

The contradictory objects of danger and safety has always been throughout the production process. Safety is mostly service for the production: First, it could protect human, which is the most important productivity factor for production; second, it could maintain and protect means of production and production environment, so that the production technology's function can be bring into full play. Safety activities are on the premise of safety investment, which means all the manpower, material and financial resources input into safety activities.

Safety investment will inevitably produce safety output, also known as safety benefits. Safety benefits can be divided into economic benefits and non-economic benefits, and this article mainly focuses on the safety economic benefits. As time goes on, safety economic benefits will general experience five stages: Ⅰ, phase of no benefit; II, phase of low benefit; III, phase of sustained strong benefit; IV, phase of benefit atrophy; Ⅴ, phase of investment ineffective (As shown in fig 1). One of the main objectives of safety economic management is to shorten phase of no benefit and phase of investment ineffective and to extend phase of sustained strong benefit, and lead toward the safety economic benefits direction, by the way of effectively control and guide of the safety economic benefit. This purpose cannot be achieved by relying only on a single safety investment, follow-up investment must be input on the appropriate time based on the initial investment[5].

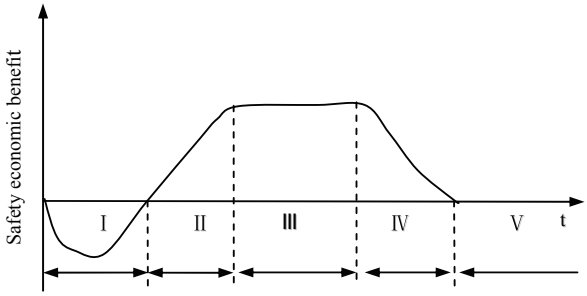

Fig. 1. Circle of safety economic benefit.

4.2. Ordering evolution of safety economic management system

When the safety economic management system meet the requirement of the dissipative structure theory, how to make the system achieve transformation from far from equilibrium state to dissipative structure? The system need to be stimulated by a small disturbance, stimulate the nonlinear area which is far from the equilibrium state, so that the safety economic management system turn from wild disorder to eutaxy. If the interaction among the elements and subsystems of safety economic management system is linearly, then there exist only the increasing and decreasing of amount, may not be any qualitative leap.

Under normal circumstances, internal disturbance does not have a huge impact to the safety economic management system. Only in the case that it's far from equilibrium state, and the disturbance is in the nonlinear area, this tiny disturbance will cause a qualitative change and a replacement of the hierarchy to the safety economic management system. Therefore, the internal disturbance of the system and the nonlinear interaction far from equilibrium state are the decisive factors that makes the safety economic management system change from far from equilibrium state to dissipative structure.

Thus, the safety economic management system could be far from equilibrium state and forms dissipative structure, through its own disturbance in the nonlinear area, without outside interference.

(1) Maintain the opening of the system.

According to point of view that entropy is the law for the change of open system's state, to maintain the system's opening, negative entropy must be introduced to the system, through the exchange of human, material, energy and information with the external environment.

In the safety economic management system, the entropy is composed of two parts:

$$dS = d_iS + d_eS \tag{1}$$

where d_iS is the entropy produced within the system, and d_eS is the entropy exchanged with the outside world. The system offset the entropy increase ($d_iS>0$) within the system by continuously absorbing negative entropy flow ($d_eS<0$) such as safety investment etc. Only if it's strong enough, the negative entropy flow could offset the generation of positive entropy, decrease the total entropy (dS) of the system, and allow the system to turn from the disordered state to ordered state in time, space and structure and form dissipative structure.

Safety economic management system should open not only to the enterprise external environment, but also to the internal subsystems. Opening to the internal subsystems, it's needed to strengthen the coordination of the various departments, links, and elements of the enterprise's internal subsystems, clarify the relationship among each part inside the enterprise, make full use of existing resources, and enhance the internal optimization ability. In addition, in the process of introducing negative entropy, we should follow the principles including optimum, timely, and moderate, should not blind introduce by rote.

(2) Make full use of fluctuation.

The dissipative structure can be formed that must be under the control of external parameter, the degree of system controlled can be expressed of some control parameters λ. When the external control parameter less than threshold, every point on the curve *a* of graph 1 are in equilibrium, can be seen as a natural extension of the thermodynamic equilibrium state, called thermodynamic branches. When the external control parameter more than threshold (the point λa in fig 2), the continuation branch a' of thermodynamic branch a become unstable , a small disturbance can cause the system to jump from thermodynamic branches to a stable branch b or c, every point of branch b or c, corresponding to some order state, called dissipative structure branch. Only the external control parameter achieve critical state, The small fluctuation in the system can be amplified by nonlinear relation to giant fluctuation, make the system mutation to the dissipative structure branch, then form a new order state . When the disturbance and shock caused by the fluctuation movement reach or exceed a certain

threshold in system, Will make the structure of the original system damaged, it has provided new orderly structure with possibilities; Instead, the new system want to keep their own, It must control system fluctuation movement within a certain threshold value, Otherwise, ordered structure will be replaced by new ordered or disordered, arise a new bifurcation. As the state corresponding to λ_b and λ_c shown in fig 2[6-7].

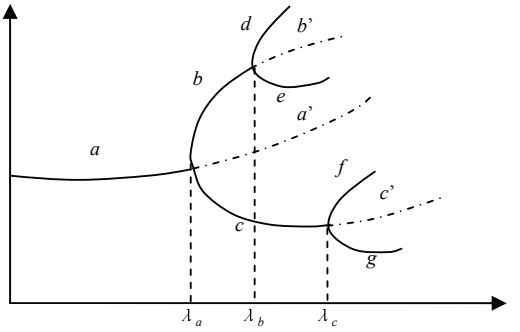

Fig. 2. Schematic diagram of system bifurcation.

In order to ensure the normal order of production, after the enterprise conduct initial security investment, along with the advancement of time, security benefits achieve to the continuous strong period, system exist linear mechanism, random small fluctuation will soon absorbed by system to keep a stable structure. But as d_iS increases within the system, the disorder degree gradually deepening, when the entire system entropy changes accumulative to achieve a certain critical value, the system will be controlled by nonlinear mechanism, then deprive of stability (point *a* in fig 1). At this time, if won't input negative entropy flows to system timely (such as a follow-up safety input) to control the system, safety economic system will enter in the interests shrinking period (section IV in fig 1). Conversely, if input negative entropy flows to system timely, and $|d_eS| \geq d_is$, the system will form a new order state, to maintain the continuous strong period of security benefits (as shown in section *ab* of fig 3), so far as to improve the system's security interests, make it to a higher continuous strong period of safety benefit (as shown in section *ac* of fig 3).

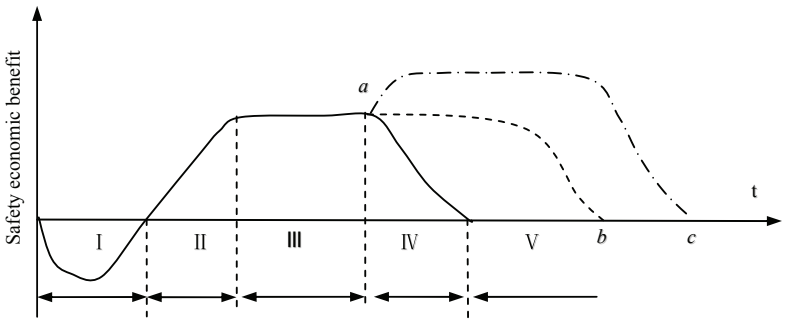

Fig. 3. Bifurcation of the Circle of safety economic benefit.

Fluctuation is an orderly moment, the fluctuation phenomenon of security economic system, such as: the investment of manpower，material resource，financial resources on the change of quantity and forms, the change of management organization, etc, all of these can affect the development of system.

Use system fluctuation mechanism should grasp the objective law of the phenomenon of fluctuation. Take proper measures and methods, such as improve the scientific and technical content, management means, optimization system function of safety economic system, and finally developed these phenomenon of fluctuation to giant fluctuation from small to big, from part to the whole , make the system formed structure, function and orderly to new heights.

In the use of fluctuation phenomenon, on one hand we should seize the opportunity, monitor each parameter changes of safety economic system in time, make the system evolve toward managers expect branch and more perfect mechanism, do some relevant cleaning, By using self-adaptive and self-organization effect of a nonlinear mechanism to form a new stable

and orderly structure. On the other hand, should pay attention to the complexity of presentation in the process of fluctuation, such as the temporary instability of system, the imbalance of related proportion, these should be attention timely, and serious study, then give a reasonable disposition.

5. Conclusions

This article applies the dissipative structure theory to safety economic management system, and demonstrates the dissipative structure property of it. Analyze the circle of safety economic benefit with the application of the theory of dissipative structure, describe its operating mechanism, and put forward thinking of leading safety economic management system to develop from disorder to order.

(1) Safety economic management system is open and farm from equilibrium state, there's a complex nonlinear relation among the internal elements and subsystems, and external and internal fluctuation significantly impact the system's stability, so the dissipative structure theory can be used to analyze this system.

(2) By continually inputting negative entropy flow such as timely and effective follow-up safety investment to the safety economic management system, we can lead the system to far from equilibrium state, extended the phase of sustained strong benefit, and improve the overall safety benefits.

(3) To promote the safety economic management system evolutes from disorder to order, we may start with maintaining the openness of the system and making full use of fluctuation.

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