

# A Study on Transmission Mechanism of Financial Supervision with Chaos Theory

## UNE ÉTUDE SUR LE MÉCANISME DE TRANSMISSION DE LA SUPERVISION FINANCIÈRE AVEC LA THÉORIE DE CHAOS

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**Abstract:** The linear rule was a general mode in the analysis of market order and financial supervision, but it frequently caused serious deviation of the market order from the supervision goal. This paper was devoted to solve the deviation with chaos model. Firstly, it substituted the operating condition of the financial institution for market order, and defined the supervision degree as a function of effective rules and realizable level. Secondly, it took these indexes into Logistic Equation to calculate the fixed points, and simulated the complex changes of market order. Thirdly, it analyzed the characteristics of the stable numerical solution in the inter-temporal differential equation. Lastly, it explained the foresight, the exogenous, the carefulness, and the time lags of the financial supervision with chaos control theory. It deduces that when the supervision degree falls into [3, 3.554], the supervision can lead to a well-ordered market.

**Key words:** nonlinear control, market order, financial supervision, transmission mechanism

**Résumé:** La règle linéaire était un mode général dans l'analyse de l'ordre de Bourse et de la supervision financière, mais elle a fréquemment causé la déviation sérieuse de l'ordre de Bourse du but de surveillance. Cet article a été consacré pour résoudre la déviation avec le modèle de chaos. D'abord, il a substitué la condition de fonctionnement de l'institution financière à l'ordre de Bourse, et a défini le degré de supervision en fonction des règles efficaces et du niveau réalisable. Deuxièmement, il a pris ces index dans l'équation logistique pour calculer les points fixes, et a simulé les changements complexes de l'ordre de Bourse. Troisièmement, il a analysé les caractéristiques de la solution numérique stable dans l'équation différentielle intertemporelle. Finalement, il a expliqué la prévoyance, l'exogène, l'attention, et les laps de temps de la supervision financière avec la théorie de contrôle de chaos. Il déduit que quand le degré de supervision tombe dans [3, 3.554], la supervision peut mener à un marché bien-commandé.

**Mots-Clés:** contrôle non-linéaire, ordre de Bourse, supervision financière, mécanisme de transmission

### 1. INTRODUCTION

Finance is a key to modern economy, and its safety is very important to the whole economic activity. It is emphasized in National Finance Conference that we must strengthen the finance supervision to maintain the safety of finance, to improve the supervision system and

supervision skill. But with the change of the space, the object and the environment, traditional finance supervision mode which based on simplicity and certain is facing more and more challenge. For example, the supervisor always faces such a question as why the supervision with the certain goal can not get the expected effect, even sometimes the result is opposite to the expect.

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Under the traditional mode which always ignores the importance of supervision process, supervisor tends to accept the idea that there is a certain relationship between financial supervision and market order, and also thinks that market order is the result of some dedicated supervision method. If occurring some error, it should be explained by external noise source, and they should be in the expected period domain. Otherwise, such a machined determined research mode is more and more unfit to complicated finance situation, and can't explain the chaos and complex situation of the finance system, and always causes a disagreement between the expected goal and the actual effect. As a result, a possible disaster to economic prediction and macro economic appears sometimes. According to this, we accept the idea that it is very important to study the transmission mechanism of the financial supervision basing on nonlinear mode.

**2. CHAOS CONTROL MODEL**

G.Nicolis and Prigogine( 1986<sup>3</sup>)pointed that (system's) evolution can be realized by suitable imbalance restriction.....evolution effected by some parameters changes in some issues, it can be restricted from outer side. That means the outer parameter not only can control the nonlinear movement, but also can change the situation of the system.

According to this, assuming market order as  $X$ ,

$$\frac{\partial X}{\partial t} = F(X, u)$$

supervision as  $u$ , we get . With Taylor Rule, ignoring the high rank, discretizing the equation, changing subscript to  $t$ . At last, we get the Logistic Function:  $X_{t+1} = uX_t(1 - X_t)$ ,  $X \in [0,1]$ ,  $u \in [0,4]$ . The whole nonlinear system varies with complex status while the control parameter changes. In the whole repeated solution process, the parameter  $u$  controls system to chaos or to order.

**3. ASSUME INDEXES OF MARKET ORDER AND SUPERVISION ORDER**

Assume:  $X_t$  as the index of finance market order.

Since the state-owned commercial banks still play an important role in the current finance system of China, especially in the banking system, we regard the running of the state-owned commercial bank as a replacement

index of current finance system market order<sup>4</sup>.

In February 2004, according to the Law of People's Bank in China, the central government issued the Measure of Examination and Evaluation of Chinese Bank, trusted China Banking Regulatory Commission to examine and evaluate all the commercial banks in China. The general evaluation indexes were classified by 4 classes and 13 items<sup>5</sup>, and the sum of each individual evaluation was the bank's evaluation score, averaged all the sums according to the scale of the bank capitals and loans, then got  $X_t$ .

At the same time, since supervision always appeared in a form of a series regulations and laws, we analysis the related laws suit for the state-owned bank issued recently. The supervision order to finance system should be the realizing function of supervision to system.

Assume :  $u$  as the disturbance that supervision to finance system.

$R_i$  = the certain supervision methods ;

$D$  = the degree of regulation realization ;

$\varepsilon$  = other dependent factor.

So,  $u = g(\{R_i\}, D, \varepsilon)$ , and  $\{R_i\}$  mean the random combination of supervision method. Obviously, different combination lead to different intensity of supervision.

In the past, there are some criticizes about Logistic equation, it is said this equation can not apply to multi-variety system, now through the introducing the multi-varieties of the definition of function  $u$  and  $X$ , the problem can be resolved.

**4. TRANSMISSION PROCESS AND EFFECT**

For finding the stable point, we transform the equation

$$\text{to } \begin{cases} y = x \\ y = ux(1 - x) \end{cases} . \text{ There are two stable points in } \begin{cases} O : x = 0 \\ A : x = 1 - \frac{1}{u} \end{cases} .$$

When the index of supervision disturbance  $u \in [0,1)$ , choose a random  $X_0 \in [0,1)$  to repeat solute in computer, the result will tend to be a fixed

<sup>4</sup> It is about the Bank System.  
<sup>5</sup> Consult to Measure of Examination and Evaluation of Chinese Bank.

<sup>3</sup> G.Nicolis. *Prigogine, Research Complexity*. Sichuan Education Press, 1986, P58

point soon. We can approve  $|f'(x_0)| = u < 1$ <sup>6</sup>. It shows that too loose supervision can not affect the market order so much. Since the goal of effect the market can not reach, so the supervision is no useful now.

When the index of supervision  $u \in (1,3]$ , for the point of O,  $|f'(0)| = u > 1$ , so point of O is not a stable point. For point of A,  $|f'(A)| = |2 - u| < 1$ , so it is a stable fixed point. it shows, for any  $X_0 \in (1,3]$ , the marked will lead to a stable status , and the status belongs to the region  $[0, \frac{2}{3}]$ .

**Table 1 Logistic Function Parameter<sup>7</sup>**

Stable point	$\mu_n$	$(\mu_n - \mu_{n-1})/(\mu_{n+1} - \mu_n)$
1-2	3	
2-4	3.4494877	4.751466
4-8	3.5440904	4.656251
8-16	3.5644073	4.668242
16-32	3.5687594	4.66874
32-64	3.5696916	4.6691
64-128	3.5698913	4.669
128-256	3.5699340	4.669
.....	.....	.....
chaos	3.5699457	4.669201661

When the index of supervision  $u \in (3, 1 + \sqrt{6}]$ , since  $f'(0) = u > 1$ , so the point is not stable, and  $|f'(A)| = |2 - u| > 1$ , so point of A is not stable either. Through repeatedly solve by computer, the initial value  $X_0$  lead to a pair of fixed point,  $\{X_i\}$  bounce between these two values. Market is stabled in a dynamic static.

When the index of supervision  $u \in (3.449, 3.545]$ , the previous stable value became unstable again and produce the new unstable point,  $X_n$  bounced at four points, market reached a dynamic stable status on these status.

This process can be simulated repeatedly as the following table 1.

From table 1, we know that with the strengthen of supervision enforced, market undergoes a cycle. Firstly, stable at a point, then lost balance, re-stable at two statuses, then re-lost balance, re-stable at four status, then re-lost balance...the process repeated again and again, till the index of disturbance large than 3.57, we

can't find the dynamic status value in the market, time series  $\{X_i\}$  became random in region  $[0,1]$ , the status at the moment is chaos.

Although in arithmetic, chaos have the clear definition, but I think chaos is a relative subjective concept, and it depends on the so called tolerance. For example, we can regard the market status after 512 status as chaos, or regard the market status after 256 status as chaos. Considering China's supervision level and real market situation, perhaps to decreased request of the precisely index is a better choice, that means to widen the supervision region to more left extent.

When  $u=4$ , we can see that after some times repeat solution,  $\{X_i\}$  spread all the region  $[0,1]$  soon. It shows too much supervision is harmful.

### 5. REASONABLE SCOPE OF FINANCIAL SUPERVISION

How to get the best supervision effect? In fact, any discrete point doesn't exist any actual meaning, so we must find a reasonable scope of financial supervision, in this scope, the multiplicity, regularity, sensitivity and tolerance must be exist, and the order of financial market can be stabilized in our expectation.

Consider the Measure of Examination and Evaluation of Chinese Bank, the measure takes 100-score-system to evaluate the operation quality of commercial bank. 100 score, the highest score, means most perfect bank, 0 score, the lowest score, means worst bank. In China, it is a good bank if its average score is more than 30. For easy deal, we minify the score 30 times<sup>8</sup>. That means  $\forall X_i \in [0,1]$ , if  $X_i > 0.3$ , then market is good. So we consider the original equation:

when  $u \in (0,1)$ , existing one stable point  $X_n = 0$ , it is not belongs to scope  $(0.3,1)$ , so requirement can not be satisfied;

when  $u \in (1,3)$ , existing one stable point  $X_n \in (0, 0.667)$ , part of the value not belongs to scope  $(0.3,1)$ , so requirement can not be satisfied;

when  $u \in (3, 3.449)$ , existing two stable point  $X_{n1} \in (0.667, 0.85)$  and  $X_{n2} \in (0.44, 0.667)$ , both of them belong to scope  $(0.3,1)$ , so requirement can be satisfied;

<sup>6</sup> Consult to the characteristics of Lyapunov Stable Point.  
<sup>7</sup> Huang Runsheng, *Chaos and Application*. Wuhan University Press, 2000, P131

<sup>8</sup> Because Logistic Function need  $X \in [0,1]$ .

when  $u \in (3.449, 3.544)$ , existing four stable point  $X_{n1} \in (0.3365, 0.44)$ ,  $X_{n2} \in (0.44, 0.52)$ ,  $X_{n3} \in (0.82, 0.85)$  and  $X_{n4} \in (0.85, 0.883)$ , both of them belong to scope  $(0.3, 1)$ , so requirement can be satisfied;

when  $u \in (3.544, 3.57)$ , existing non-stable point not belongs to scope  $(0.3, 1)$ , so requirement can not be satisfied;

When  $u \in (3.57, 4)$ ,  $X_n$  enters into chaos status, opposite to our supervision goal, so we don't consider this situation.

Above all, only region  $(3, 3.554)$  can satisfied the need, and this is the reasonable scope of financial supervision. When taking any values from the control parameter  $u$  in this region, we can let market order enter an ordered market system by repeated solution. It explain theoretical that there exist a possibility of order market system to which supervision can lead.

## 6. NEW EXPLANATION TO THE SUPERVISION

Above study provides a new explanation to the finance supervision.

Firstly, new hypothesis were provided for the requirement of supervision. Finance is a complex macro-system which leading to self-organization, and is possible to appear balance in the critical. At this point, any tiny event can result to a large change and chaos. To prevent the great loss and damage beyond its critical, supervision must fulfill before the damage happens, so the supervision can help to change the status, and loss can be decreased. From this point of view, supervision must be a prevention not a compensation to damage, so supervision must have the nature of foreseeing.

Secondly, new hypothesis criticizes the point that policy is born as internally. In the past, most of the supervisor tend to believe that policy is born as internally, and it completely depends on the will of policy maker, so supervisor can have most of the freedom to make any policy. But according to the point of dynamics, long period is sensitive to the initial condition and parameter, this forced the supervisor to consider policy repeatedly before they make a decision, so policy is more and more depends on the effect of other aspect in the system. The supervision is no more internal, but external.

Thirdly, supervision must be careful. Model shows, quite different results and complex dynamic state can be formed after many times solution by tiny initial changes of supervision. This may be the reason that why we get different results by almost same supervision regulation. Supervision must be careful, and must consider the aspect of direction, aim, scale and scope and dimension.

Finally, supervision has the nature of time-delay. Supervision and market are a pair of closely related varieties, in the last, as a rule, people think there are simple relationship of point to point corresponding. But, I think, the relationship between them is not so simple, there exist one kind of nonlinear repeated solution relationship in it. We can only influence the initial market order  $X_1$ , but through repeated solution,  $X_n$  may be very complex, and we can not influence directly the last market order  $X_n$ . Evolving  $X_1$  to  $X_n$  needs time. This forced the supervisor must be not only careful but also patient, and should not neglect the time-delay of supervision effect.

It is a job which still few people notice to quantize the supervision and market order and to study their relationship and evolution, and it is a hard and effort consuming job but maybe useful at the same time. I tried some steps but not very perfect, hoped my paper can help the study of finance, and hoped to get more suggestion.

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