The study on the evolution of real estate industry based on the theory of self-organization

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Abstract: Based on some basic principles of self-organization theory including dissipation structure and synergy, the author analyzes the condition, dynamic and evolving route of the self-organization evolution of the real estate industry, and builds synergetic evolution model, calculates out the order parameter of the real estate industry. The paper supplies new methods and tools for further research of real estate industry and contributes to reference of the government for its direction of macro-control.

Key words: real estate industry; dissipation structure; synergetics; order parameter

1 Introduction

Real estate industry, which can be influenced much by the factors of policy, macro-economy and society, has grown up to the backbone industry of national economy through the development of more than 20 years since the opening-up and reform. Meanwhile, with the rapid development of real estate industry, there are some challenges appearing, such as low industry concentration degree, small scale, too rapid increase of investment, unreasonable supply structure, and high housing price. There are all kinds of reasons for this, but insufficient recognition of self-organization mechanism and evolution route of real estate industry is probably an important one. This paper tries to introduce self-organization theory into the evolution research of real estate industry, hopes to offer a new route for the thorough research of real estate industry.

2 Connotation of self-organization theory

Self-organization theory, which has not formed a whole theoretical system, is still a theoretical crowd [1]. It mainly consists of dissipative structure theory, synergetic theory, catastrophe theory, fractal theory and chaotic theory etc. Each theory has its own method, however, seen as a whole, it exists a unified self-organization methodology (Fig. 1), which connects each theory mutually. Each theory has different research objects, but with common features, which are all nonlinear complex systems, or nonlinear complex courses of self-organization formation.

The evolutionary process of real estate industry that is an open complex system, can be analyzed with self-organization theory as follows: dissipative structure theory resolves the environmental condition problems of the self-organizing of real estate industry; synergetic theory resolves the dynamic problems of the self-organizing of real estate industry, and so the overall frame of evolutionary condition and dynamic of real estate industry is established.

3 Analysis of dissipative structure in real estate industry

Dissipative structure, which means an open system far from equilibrium state exchanges material, information and energy with external environment. When the external condition reached a threshold value, the system may convert from existing chaos disordered status to an ordered status in time, space and function dimensions, forming a new ordered structure [2]. The openness, nonequilibrium, nonlinear and fluctuation is the source of complexity and diversity of the industry economic phenomena, and is also the precondition and cause of the industry self-organizing evolution.

3.1 Openness

The development of real estate industry is in the big environment of national economic development, exchanges material, information and energy with external environment continually, which makes the resource flow inside and outside the industry according to efficiency.

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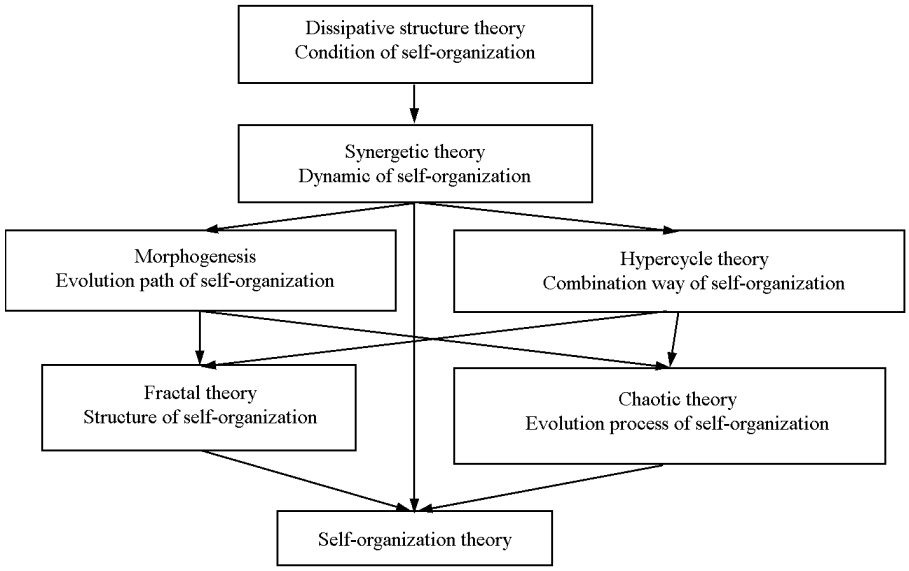

Fig. 1 Framework of self-organization theory

3.2 Nonequilibrium

Real estate industry system is of big difference both in time and space dimensions. It is far from equilibrium state. From the view of time, real estate industry is speeding up the reshuffle; from the view of space, the development of real estate industry is different widely between areas. The real estate industry in southern and eastern areas such as Guangzhou, Shenzhen and Shanghai has fully developed while in central and western areas is still comparatively backward. The whole system is in the state of unequilibrium.

3.3 Nonlinear

Every component and level of real estate industry is very complex interconnected to each other. It includes positive and negative feedbacks, some of which are obviously non linear. For example, one small change of the leader of the industry may lead to other followers' non-rational imitation, making very big impact on the whole industry. Another example is, input-output ratios of different companies will show nonlinear relationship because of their varieties in profitability and profitable model.

3.4 Fluctuation leads to order

Due to the openness of real estate industry, every element within it should be affected by external environment and been changed continually. As a result of the nonlinear of subsystems and elements within subsystems, some disturbance of single element may lead to the fluctuation of the whole industry. The fluctuation of real estate industry remains all the time. When micro-fluctuation transmits to macro-fluctuation as a result of nonlinearity, the real estate industry will appear new industrial structure and function. Above all, the real estate industry system is a typical dissipative structure which meets the condition of self-organization.

4 Analysis of evolution dynamics of real estate industry based on synergy

If the application of dissipative structures can make the system handle relations with the external environment better, then the application of synergy can better deal with the synergistic effects between the various sub-systems within the system. Synergey makes a comprehensive study of the action of internal factors during the development of self-organization, finds out the synergistic effects as a result of the competition, cooperation between a large number of subsystems within the system, and the coming control process of the order parameter. Synergy is the method of the system dynamics of self-organization.

This paper firstly determines the characteristic indicators of the real estate industry system; establishes the synergy model of the real estate industry; accordance with slaving principle, makes use of adiabatic elimination technique to determine order parameter of the real estate industry system, finally makes relevant recommendations according to order parameters.

4.1 Indicator system of synergetic evolution of real estate industry

The real estate sub-systems selected in this paper are the supply side sub-system, the alternative sub-system, the consumer sub-system, the potential entrant sub-system, the real estate development enterprise subsystem[3]. According to the purpose studied in the sys-

tem, and the actual situation of each sub-system, 8 state variables are now selected from 5 sub-systems to represent the real estate industry. X_1 —the number of newly increased development enterprises; X_2 —the top 10 total operating income ratio, %; X_3 —total operating income of real estate industry, billion yuan; X_4 —non-equity capital of real estate industry, billion yuan; X_5 —the supply amount of land, 10 000 m^2; X_6 —per capita income in real estate industry, 10 000 yuan/ person; X_7 —the own fund's profit margin in real estate industry, %; X_8 —excess profits rate in real estate industry, %; The original value of each state variable is shown in Table 1. *The China Statistical Yearbook* only updated to 2005, while most original values of state variables are directly or indirectly from *The China Statistical Yearbook*, so there is no data after 2005.

Table 1 The original values of state variables

Indicator	Year									
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
X_1	-1 921	17	3 092	1 384	1 541	2 249	3 066	4 505	22 119	-2 952
X_2	5.05	4.61	3.79	4.78	4.99	4.55	3.49	4.16	3.94	4.79
X_3	1 860.4	2 085.5	2 778.7	2 730.7	4 063.7	4 973	6 564.3	8 582.6	12 831	14 238
X_4	2 959	3 381	3 903	4 183	5 220	6 551	8 244	11 191	15 163	17 375
X_5	34 048	6 641.7	10 109	11 958	16 905	23 409	31 356	35 696	39 784	38 253
X_6	108.37	132.96	172.43	295.22	451.95	498.6	513.58	554.62	483.43	530.43
X_7	3.52	-3.26	-3.06	-7.13	7.73	9.69	15.80	20.65	29.48	27.58
X_8	-6.56	-11.9	-9.99	-12.98	1.88	3.84	10.49	15.34	23.9	22

Source: *The China Statistical Yearbook* and related real estate development companies listed on the annual report

4.2 Synergetic evolution model of real estate industry

Based on the coupling and synergistic characteristics between the various sub-systems, we make quantitative research of the synergy relations between the real estate system and the various sub-systems using synergy, and build synergistic development model of the system evolution, accordance with slaving principle, make use of adiabatic elimination technique to determine order parameter of the system. The so-called order parameter is the macro-parameter introduced to describe the macroscopic behavior of the system, and the result of synergistic movement of the large number of sub-systems within the system. Once the order parameters come into being, they play roles of domination and servitude of sub-systems and system; dominate the evolution process of the system[4].

Establish synergetic evolution model of real estate industry system using of synergetic and grey system modeling methods:

1) Where $x_i(t)$ is the value of indicator i at t year ($i=1,2,\ldots,8; t=1,2,\ldots,10$), the original values are shown in Table 1. The processed data is $x_i^{(0)}(t)$ ($i=1,2,\ldots,8; t=1,2,\ldots,10$),

$$x_i^{(0)}(t) = \frac{x_i(t)-\min\limits_t x_i(t)}{\max\limits_t x_i(t)-\min\limits_t x_i(t)} \qquad (1)$$

2) Where AGO (accumulated generating operation) processing of $x_i^{(0)}(t)$ ($i=1,2,\ldots,8; t=1,2,\ldots,10$), the processed data is $x_i^{(1)}(t)$,

$$x_i^{(1)}(k) = \sum_{t=1}^{t=k} x_i^{(0)}(t)$$

$$(i=1,2,\ldots 8; k=1,2,\ldots,10) \qquad (2)$$

3) Where $dx_i^{(1)}(t)/dt$ is the change rate of $x_i^{(1)}(t)$, $dx_i^{(1)}(t)/dt$ depends on two actions: a. The internal synergistic effect between the various elements within the system that is the result of their own development and suppression. Its own development items are $a_{ii1}x_i^{(1)}(t)$, $a_{ii2}[x_i^{(1)}(t)]^2$; its own suppression items are $-b_{ii1}x_i^{(1)}(t)$, $-b_{ii2}[x_i^{(1)}(t)]^2$; b. The external synergistic effect between the various elements within the system that is the result of synergy and competition between them, the synergy items are $a_{ij1}x_j^{(1)}(t)$, $a_{ij2}[x_j^{(1)}(t)]^2$ (the synergy effect of j to i), the competition items are $-b_{ij1}x_j^{(1)}(t)$, $-b_{ij2}[x_j^{(1)}(t)]^2$ (the competition effect of j to i).

Then, the overall change rate of $x_i^{(1)}(t)$ is:

$$\frac{dx_i^{(1)}(t)}{dt} = a_{ii1}x_i^{(1)}(t) + a_{ii2}(x_i^{(1)}(t))^2 - b_{ii1}x_i^{(1)}(t) - b_{ii2}(x_i^{(1)}(t))^2 + \sum_{j=1,j\neq i}^{8}\Big[a_{ij1}x_j^{(1)}(t) + a_{ij2}(x_j^{(1)}(t))^2 - b_{ij1}x_j^{(1)}(t) - b_{ij2}(x_j^{(1)}(t))^2 a_{ii1} - b_{ii1} = a_i,$$

$$a_{ii2} - b_{ii2} = b_i, a_{ij1} - b_{ij1} = a_{ij},$$

$$a_{ij2} - b_{ij2} = b_{ij},$$

The nonlinear equations can be changed into:

$$\frac{\mathrm{d}x_i^{(1)}(t)}{\mathrm{d}t} = a_i x_i^{(1)}(t) + b_i (x_i^{(1)}(t))^2 + \sum_{j=1,j\neq i}^{8} (a_{ij} x_j^{(1)}(t) + b_{ij} (x_j^{(1)}(t))^2) \quad (i = 1,2,\ldots,8) \tag{4}$$

4) Determine parameter a_i

Due to $\frac{\mathrm{d}x_i^{(1)}(t)}{\mathrm{d}t} = x_i^{(1)}(t) - x_i^{(1)}(t-1) = x_i^{(0)}(t)$ (5)

Then

$$\frac{\mathrm{d}x_i^{(1)}(t)}{\mathrm{d}t} = a_i x_i^{(1)}(t) + b_i (x_i^{(1)}(t))^2 + \sum_{j=1,j\neq i}^{8} (a_{ij} x_j^{(1)}(t) + b_{ij} (x_j^{(1)}(t))^2) \quad (t = 1,2,\ldots,10) \tag{6}$$

Substitute $t = 2,\ldots,10$ into the above expression respectively results in $\boldsymbol{y}_{iN} = \boldsymbol{B}_i \boldsymbol{P}_i$,

Where

$$\boldsymbol{B}_i = \begin{bmatrix} x_i^{(1)}(2) & (x_i^{(1)}(2))^2 & x_1^{(1)}(2) & \cdots x_{i-1}^{(1)}(2) & x_{i+1}^{(1)}(2) & \cdots x_8^{(1)}(2) & (x_1^{(1)}(2))^2 & \cdots (x_{x-1}^{(1)}(2))^2 & (x_{x+1}^{(1)}(2))^2 & \cdots (x_8^{(1)}(2))^2 \\ x_i^{(1)}(3) & (x_i^{(1)}(3))^2 & x_1^{(1)}(3) & \cdots x_{i-1}^{(1)}(3) & x_{i+1}^{(1)}(3) & \cdots x_8^{(1)}(3) & (x_1^{(1)}(3))^2 & \cdots (x_{x-1}^{(1)}(3))^2 & (x_{x+1}^{(1)}(3))^2 & \cdots (x_8^{(1)}(3))^2 \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ x_i^{(1)}(10) & (x_i^{(1)}(10))^2 & x_1^{(1)}(10) & \cdots x_{i-1}^{(1)}(10) & x_{i+1}^{(1)}(10) & \cdots x_8^{(1)}(10) & (x_1^{(1)}(10))^2 & \cdots (x_{x-1}^{(1)}(10))^2 & (x_{x+1}^{(1)}(10))^2 & \cdots (x_8^{(1)}(10))^2 \end{bmatrix}$$

$$\boldsymbol{y}_{iN} = \begin{bmatrix} x_i^{(0)}(2) \\ x_i^{(0)}(2) \\ \cdots \\ x_i^{(0)}(10) \end{bmatrix} \tag{7}$$

$$\boldsymbol{P}_i = [a_i, b_i, a_{i1}, a_{i2}, \cdots, a_{i,i-1}, a_{i,i+1}, \cdots, a_{i8}, b_{i1}, b_{i2}, \cdots, b_{i,i-1}, b_{i,i+1}, \cdots, b_{i8}]^{\mathrm{T}} \tag{8}$$

Due to $\boldsymbol{B}_i$ is 9×16 matrix, according to the least-squares criteria, then $\boldsymbol{P}_i = (\boldsymbol{B}_i^{\mathrm{T}} \boldsymbol{B}_i)^{-1} \boldsymbol{B}_i^{\mathrm{T}} y_{iN}^{[5]}$, $\boldsymbol{y}_{iN}$ is obtained according to Table 1, substitute $\boldsymbol{y}_{iN}$ into $\boldsymbol{y}_{iN} = \boldsymbol{B}_i \boldsymbol{P}_i$, then the relaxation coefficient of each state variable is $a_i (i = 1,2,\ldots,8)$.

a_i —the relaxation coefficient of each state variable of real estate industry is $a_1 = 1.2075$, $a_2 = 1.376$, $a_3 = 3.052$, $a_4 = 0.1842$, $a_5 = 0.2764$, $a_6 = 3.8133$, $a_7 = -2.091$, $a_8 = -3.9294$. The relaxation coefficient $x_4^{(1)}, x_5^{(1)}$ are relatively small, abutting one order of magnitude deviated from other relaxation coefficients. Through elimination of other 5 variables using adiabatic elimination technique, the remaining state variables a_4, a_5 are slow variables of system revolution. According to Haken's synergetic servo theory, fast variables subject to slow variables which are order parameter variables that determine the evolution of the system. X_4 is non-equity capital of real estate industry and X_5 is the supply amount of land lead and dominate the evolution of subsystems of real estate industry. There is no doubt that land and capital are two main lifelines of real estate development, and the calculation results are in line with the reality.

4.3 Analysis on order parameters

Through the analysis on two order parameters of real estate industry, this paper provides suggestions for relevant departments of government, and offers decision references for various bodies of the market.

4.3.1 Land policy

China's long-term land policy should strengthen intensive use of land in order to achieve the same effect of increasing the amount of land supply, which can increase the synergy degree of land and development capital, and is conducive to the sustainable development of the real estate industry. a. Establish reasonable urban development strategy according to the urban development phase; b. Carry out urban land readjustment actively, and make full use of urban stock land; c. Lay stress on the development of urban connotation and space utilization of land; d. Standardize government behavior, and exert the role of market upon allocation of land resource; e. Optimize industrial structure.

4.3.2 Capital supply

At present, the own funds of real estate enterprises seldom exceed 25 % in China, resulting in high financial risk and increasing systematic risk too. Real estate enterprises should expand financing channels, change current status which use bank credit capital as main source of capital, and reduce systematic risk. At the meantime, they should increase the equity capital financing and reduce financial risk.

1) Suggestions for governments: a. Specific rules and standards should be established for real estate enterprises if necessary. b. Establish the second board, the third board and property rights exchange markets. Provide a platform for the listing of real estate enterprises of different scales and types. c. Further developing and perfecting enterprise bond market. d. Loose the restriction that unitrust can not exceed 200 shares; provide condition for listing and circulating of real estate trust. Meanwhile, strengthen disclosure requirements

of trust products. e. Issue law of real estate investment trusts fund and other relevant laws, encourage private capital and foreign capital to reasonably flow to real estate and other industries of high profit rate. f. Encourage investing real estate trust and investment trust fund, and issue relevant preferential policy of tax.

2) Suggestions for capital market and financial institutions: a. Using various creative modes such as assets securitization and trust to expand financing channels for real estate enterprises. For example, issue bond of real estate enterprise overseas, REITs and equity real estate trust, and establish real estate investment fund. b. Help real estate enterprises resolve the problem of the long-term fund bottleneck. For example, help regular real estate enterprises that meet the requirements to enter into stock market, issue the long-term trust product and enterprise bond. c. When design product and financing, help real estate enterprise to standardize operation, avoid risks and ensure the interests of the investor. Financial institution shall strictly investigate the practical situation of real estate enterprise before financing, and control fund flow and operation situation after financing, promote sound development of financing market of real estate.

3) Suggestions for enterprises: a. Make long-term financing strategy in accordance with its own development target, try to positively expand different financing channels, and avoid the risk of financing channel sole. b. Real estate enterprises that meet the requirements should enter the stock market in order to establish sustainable financing channel, and reduce the risk of financing channel sole through issuing bond, trust, real estate fund, project financing and other modes. c. Standardize the business, and improve the use efficiency of funds, enhance own business performance as soon as possible, repay or attract investors through generous return, promote the healthy development of financing market of real estate.

5 Conclusions

Self-organization methodology is a cross science which studies on natural and social sciences [6]. Real estate industry acts an important role in social economy field. Self-organization theory can be an important tool which studies on the evolution of real estate industry. Depending on the theory of dissipative structure which belongs to self-organization theoretical crowd, firstly, this paper proves that real estate industry is characteristics of openness, non-equilibrium, non-linear and fluctuation, so that real estate industry is a dissipative structure, and meets the conditions of self-organization. Secondly, establishes the synergy evolution model, and obtains order parameter of real estate industry in our country. Meanwhile, puts forward relevant suggestions about order parameters in order to promote the sustainable development of real estate industry in China.

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