

# Urban Planning Formulation Problems in China and the Corresponding Optimization Ideas under the Vision of the Hypercycle Theory

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**Abstract**—Systematic Science reveals the complex nonlinear mechanisms of behavior in urban system. However, when confronted with such system, most city planners in China are still utilizing simple linear thinking to learn and understand this open complex giant system. In this paper, the hypercycle theory was introduced, which is one of the basis theories of systematic science. Based on the analysis of the reasons for the failure of current urban planning in China, and in consideration of the nonlinear characteristics of the urban system as well, optimization ideas for urban planning formulation were presented such as the shift from blueprint planning to progressive planning and from the rigid urban planning management control to its dynamically monitor and in time feedback.

**Keywords**—Systematic science, hypercycle theory, urban planning.

## I. INTRODUCTION

IN 1948, Bertalanffy, published his book "Problems of Life"—wrote the "life issues" [1], which symbolized the beginning of systematic science. Afterwards, systematic thoughts were rapidly introduced into other disciplines like physics, psychology, sociology, etc. And systematic science, therefore, becomes the fastest developed comprehensive science in 20th century.

City is considered as a typical open complex giant system [2]. Related scholars have already begun to use the perspective of systematic science to conduct researches on cities in China. For example, the city and its host region was considered as a giant complex open system [3] based on the basic rules of the systematic theory, a number of development proposals were proposed for city related disciplines; Cheng Kaiming [4] made comments on papers from home and abroad about city self-organization, and on the basis of analysis about the self-organizing feature of the whole urban system and its subsystems' fractals and dissipative structures, he proposed the idea that the self-organization feature of urban system contributes substantially to the promotion of sustainable urban development; Cai Hua [5] studied on self-organization properties of the complex system, and then presented the policy suggestions for optimization of urban system structure in Heilongjiang Province.

Based on the overall characteristics of urban system, most studies took the operation of urban system and its subsystems in consideration, some optimization measures were subsequently

proposed. It is generally accepted that urban system has hypercycle characteristic, however, it is always ignored by city planners when they are formulating urban planning, which to a considerable degree, causes problems during the formulation of urban planning. Bearing this in minds, the hypercycle characteristic of urban system was analyzed, some problems of urban planning formulation were revealed, and some corresponding improvement measures were presented.

## II. HYPERCYCLE CHARACTERISTICS OF URBAN SYSTEM

### A. Hypercycle Theory

German physicist M. Egan introduced the principle of universality in the domain of biology, studied the origin of biological information during the self-organization process of biological macromolecules, and established a hypercycle model for the origin of life, thus the hypercycle theory was founded. Not only in life science, wide attention was attracted in life science, philosophy as well as in social science [6]. M. Egan divided various biochemical cycles into three levels: the reaction cycle, the catalytic cycle and the hypercycle. Hypercycle theory believes that the catalyst will regenerate after reaction cycle; the product of catalytic cycle itself can be used as a catalyst to guide reactant regenerate the product; hypercycle is not only self-regeneration and self-replicating, but also self-selection and self-optimization, and thus evolves to a higher complexity [7]. Therefore, the hypercycle system is a self-replicating and self-evolution nonlinear system with the mutation property.

### B. Hypercycle Characteristics of Urban System

According to the systematic science, urban and rural area can be seen as a highly nested open complex giant system that was composed of numerous subsystems (natural, economic, demographic and other subsystems). Each subsystem evolves by itself while participating and catalyzing the evolution of other systems. For example, the growth of the urban population laid the foundation for economic development, the development of urban economic system also provided material basis for urban population aggregation, and subsequently guided the growth of the urban population. Numerous systems with interactive relationship and reciprocal causation constitute the hypercycle structure of urban system. Overall, hypercycle characteristics of urban system acts in the following areas:

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### 1. Urban System is an Open System with the Characteristic of Self-Evolution

According to the second law of thermodynamics, in a closed system, energy can only be irreversibly transformed along the direction of decay, that is to say, its entropy is always increasing. In an open competitive environment, there are only two options to ensure the system evolves towards an orderly direction, one is to optimization itself to reduce the increasing rate of entropy, and the other is to introduce the negative entropy from outside to offset its total increasing entropy. Take urban space system for example, different land location produces various potentials, thus induces human activities mobile from low to high potential, negative entropy is therefore formed from order to disorder [8]. Various elements of urban system rely on the function of system's hypercycle, through which new land location is formed during the process of their competition and cooperation. The continuous recycling of process -- "original location → spatial redistribution of elements → New location" completes the overall evolution of urban space system. In the process of competition and cooperation, the existing obsolete elements in urban system were eliminated; new elements in accordance with the requirements of the times were more competitive so they occupied good location. During the above process of the survival of the fittest, urban space was continuously expanding, and population aggregation ability was strengthening increasingly. Gradually, small-sized cities were changed into median-sized cities, and the latter into large-sized cities. The urban system as a whole presents a ceaselessly evolution process.

### 2. Urban System Has a Character of Mutation

Urban complex open giant system is made up with several subsystems, both the acting mechanism of them and between them are different. The overall evolution of the system is achieved by continuous or non-continuous action of subsystems [9]. Non-continuous action is usually manifested in the form of subsystem's mutations. According to the "Proposed species" concept of hypercycle theory: Proposed species are temporary, unstable mutant. Form a new temporary hypercycle system together with the existing hypercycle system, after system screening itself, preserving the proposed species which is good for the system itself, fixing it to become part of the system, prompting the system grow to a higher complexity level. Take political sub-system of urban system for instance, the promulgation of the law and the policies (such as "People's Republic of Urban Planning Law" was enacted) can be regarded as a mutation of urban political sub-system and has an important impact on the development of urban system. In a certain period of social development, if the implementation of new law, policies make the urban system run more orderly and efficient, it will bring great external effects, ultimately the new law, policies become part of the political system; Whereas, if the law, policies do not meet the actual needs of the current stage of social development, it will produce a very high operating costs in its implementation process, and may even lead to social unrest. Accordingly the law, policies will be

modified or even abolished.

### 3. The Nonlinear Interaction Characteristics between Sub-Systems of Urban System

Urban giant system is consists of several subsystems, each subsystem is complex open giant system and functions between them are highly coupled. In urban system, there is nonlinear relationship between the various subsystems: the subsystems interact with each other, exchange of the frequency, form the utility that an integral is not equal to sum of the part, emerge new substance "part" does not have, therefore simple proportional relationships and superposition principle cannot be used to measure [10]. For example, urban master planning divides reasonable functions to the various towns and villages, so that the link between the various elements of the system become more closely, the interaction become more frequent, the whole system (urban areas) showed the feature that its constituent elements (separately towns) do not have when the system in a closed state. As the urban agglomeration research becomes hotspot recent years, some scholars [11] have suggested that urban agglomeration is a huge system, the systematic coordination goal is to achieve the whole urban agglomeration system harmonious and orderly development: that is to make the comparative advantages of each subsystem into full play, produce synergies that the whole is greater than the sum of its parts.

#### *C. The Main Problem of Urban Planning Formulation Under the Vision of Hypercycle Theory*

The action of urban planning formulation is a part of urban political system, the main means is to regulate urban spatial system, and the purpose is to promote comprehensive, coordinated and sustainable development of urban economy and society. The current planning formulation system is mainly composed of urban system planning, urban planning, town planning, rural planning and village planning. Urban planning and town planning include overall planning (hereinafter referred to as the master planning) and detailed planning; detailed planning includes controlling detailed planning (hereinafter referred to as control regulation) and the construction of detailed planning (hereinafter referred to as the revised Regulation). In the current accelerated developing phase of urbanization, urban structures become increasingly complex so that internal subsystems interacts each other more closely, meanwhile mechanism of action becomes more complex as well. However, with the rapid development of urban areas, planning formulation has increasingly shown its lag. The author believes that the main problems are as the following:

#### 1. Stiffness of the System Settings, Self-Adjusting Ability is Not Strong

Take urban planning as example, control regulation takes master planning as direct basis, that means revised regulation must meet the requirements of the specified index that control regulation calls for. Seemingly this three levels system (master planning - control regulation - revised regulations) can effectively guide the development of urban space no matter in

spatial extent, intensity of control or depth of formulation. But because of the mutations characteristics of urban hypercycle system, it is unlikely that urban develops completely in accordance with the planners' expectation, or sometimes even deviate from the direction that the planners had expected. Under the complex mechanisms of action inside the urban system, with the current master planning - control regulation - revised regulation three levels of urban planning system, as long as one of a upper planning fail, will lead to lower planning lacking of the guiding basis, and then result in planning formulation loss of rationality. What is more, facing up with the failure of the upper planning, revision is the only measure to take due to the lack of a self-regulating mechanism that is able to quickly response to. Especially when the current planning approval procedures is so complicated, driven by the immediate profits, parts of the government even put together the lower planning to make up of the upper planning, such as using control regulation to piece together the master planning, resulting in no way to protect the public interest, and in disorder situation that planning legal effect disappearing.

2. Ignores the bottom-up feedback mechanism of space system

Currently the public policy attribution of urban planning has increasingly caused attention, planning formulation, public participation in the implementation process are rising either in the depth and breadth, this can be seen as a bottom-up feedback mechanism that planning formed as part of the political subsystem. While in planning formulation process, the feedback of space subsystems is ignored. As a result of old thinking that "master planning is in charge of control regulation," "control regulation is in charge of revised regulation", "urban is in charge of village ", planners gradually form simple one-dollar-thinking. Whether the formulation and the implement of a detailed plan would affect the effectiveness of master planning or not? Whether the formulation on rural development plan will have impact on the construction of city's central business area? According to "urban Planning Act," when the contents need to be modified in control regulation are related to the mandatory contents mentioned in master planning, the master planning should be modified first of all. Then, if the contents need to be modified in control regulation are not related to the mandatory contents of master planning, does that mean the modification of control regulation will not affect the implementation of urban planning at all or only have minimal impact, or the effect can even be ignored? This paper considers that just like the butterfly effect describes, under the function of the urban hypercycle system, even the tiniest change can be enlarged to influence the whole urban area through the dynamic mechanism of inner system. That means frequent modification on lower planning will lead to the loss of upper planning's guiding significance even though the changes of lower planning does not involve the core or mandatory contents of upper planning. The adjustment of a single block will certainly bring overall urban space benefits changes and ignore the feedback mechanism of space system in planning, finally, lead planning adjustment into heavy task and poor utility situation.

3. Over-Emphasis on the Amount of Indicators in Planning Formulation

In the current planning formulation, the planning objectives are mostly decomposed into quantities of different types of indicators (such as the planned number of population, land scale, scale of all kinds land). With the deepening of research, related scholars adopt increasingly complex indicators quantitative methods, so they could reach a reasonable prediction of the city after full reasoning and computing. But in reality the results are often unsatisfactory because of the nonlinear relationship between the various subsystems of the hypercycle system, so it is inevitable that the system cannot be completely accurately predicted. In particular this is an open complex giant urban system with a collection of several subsystems of social, natural, economic, etc. And each subsystem is consists of several open complex giant systems of next level, action mechanisms of each systems are different and along with a mutation. Take population forecasts as example, it is impossible to collect all the factors affecting population change, don not mention the interaction between these factors themselves are constantly changing. Just as academician Zhou Ganzhi said, the strength of the interaction between the various subsystems of urban system changes with time and space, and the interaction between subsystems could trigger a chain reaction of other related subsystems, furthermore, considering its openness and complexity, it cannot be handled with a reductionist approach, we cannot deal with it using approach as same as classical statistical physics used to take to handle open simple giant systems. Through the above analysis, the author holds that in the face of urban hypercycle system structure, the thoughts hoping to guide planning formulation through accurate predict the amount of indicators clearly has a non-adaptive. In practice it is common that planning utility reduced due to excessive emphasis on the amount of planning indicators: for example, the master planning is just approved by relevant departments, but because the reality land development has exceeded the size of the expected plan so that master planning is also facing changes.

*D.A Number of Ideas to Improve the Formulation of Urban Planning*

1. On the situation that the current rapid development of urban areas and the increasingly complex evolution of systems, the planning based on indicators quantitative analysis is difficult to achieve a reasonable guidance for urban space (for instance, the urban land scale beyond what the master planning is expected results in a total master planning failure). In essential, the complexity of the urban system does not lie in large numbers of subsystems, but reflect on the effecting relationship between each subsystem in pace of time and space changing. When urban planners confront an open complex giant system, they must change the current thinking, guide urban planning system from controlling quantitative change to the relationship change. As materialist dialectics reveals, in dealing with contradictions, we should focus on seizing the main one. Obviously, China has a vast territory, the level of economic development and intrinsic resource endowments

between different areas are huge, so the main contradiction different areas faced in the development process are also different: Likely, the eastern coastal region has entered into the post-industrial era which use modern service industry as the main developing engine, while most of the western region is still make efforts to achieve industrialization. In short, different stages of development are faced with different principal contradictions, so planning formulation should adopt different ways of thinking.

In coastal areas, for example, on one hand they have to maintain high economic growth rates within limited resources, on the other hand, to take care of the social justice issues simultaneously pursuit of development. Therefore, as a public policy, the main contradiction urban planning has to face is the relationship between economic development, natural ecology and social justice. The ideal urban planning should be created under certain ecological patterns, by setting a series of rules as well as by rational distribution of urban space to guide the healthy mutual promotion between economic development and social justice: In all, economic development lays a good foundation for social justice; social justice in turn creates no (less) friction developing environment for economic development. Therefore, in coastal developed areas, the main task of current urban planning formulation is to develop an urban spatial layout pattern based on a virtuous cycle of efficiency – justice: composite index reflecting the relationship replace the existing single type index which is more commonly used in planning formulation, and a spatial derivative control mode that reasonably guide the social and economic develop within the limits of the ecological carrying capacity (Fig. 1) could be obtained through the constant constraint, restraint between each composite index. Land use planning can be regarded as a concrete implementation of specific spatial development patterns driven by the government or the developer, which in turn enhance the adaptability of planning formulation when face to urban system, so it could get rid of the current embarrassment due to the development of individual indicators exceeding expectation that led to the failure of the global plan.

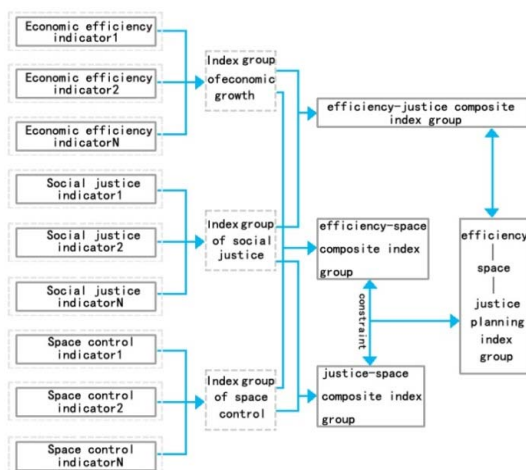


Fig. 1 Composite index replaces the existing single type index

## 2. Convert the Blueprint-Style Planning to Progressive Planning Based On Non-Linear Characteristics of System

In urban hypercycle system structure, the highly coupled nonlinear role of subsystems lead to accurate prediction of urban areas become impossible for a long time, so it is necessary for us to change the current domestic prevailed planning formulation pattern of blueprint style, to progressive style planning formulation mode based on nonlinear characteristics. Progressive planning ideas initially proposed by American scholar Lindblom, he pointed out that due to constraints of time, financial and information, human beings do not have the ability to clearly predict the future, not as good as take a more realistic approach--with limited knowledge of us mankind, with progressive ideas, continue to find and solve problems, so we can change the reality gradually [12]. Academician Hao Bailin thinks long time prediction of chaos that generated in nonlinear can only predict certain invariants, slow variables and the mean; short-term prediction depends on what state of the system is at. As pointed out earlier, under certain socio-economic condition, there is a more reasonable spatial layout development model based on relationship protection between principal contradictions of the current development stage. When the urban system is in a period of steady development, based on the relational model, we can guide and control urban space using composite index group that reflects contradiction. But as urban system continually evolve to a higher level and mutation factors inside or outside of the system (such as the big event) arise, we need to regulate the existing interests relationship based on the newly formed spatial interests protecting relationship so as to formulate a new spatial layout development model to guide the development of urban space. It is observed that the progressive feedback cycle is not a fixed time cycle, but should take the endogenous mutations of urban system and effecting circumstances come from the external system into consideration. In recent years, China has begun to attach importance to the feedback of planning: In 2009, the Ministry of Housing and Urban-Rural Development issued "implementation evaluation method of the urban master planning (Trial)" (hereinafter referred to as approach). Although the assessment of planning implementation is confirmed as an important part of urban planning at the national level, the understanding of feedback adjustment cycle still has a certain degree of deficiency: For instance, "approach" prescribes the assessment on implementation of urban master planning should be carried out once every two years in principle. Thus, in "approach", we can see the formulation of evaluation period is still using over rational blueprint-style thinking lacking of the consideration of nonlinear interactions between urban subsystems and external forces acting on the system.

As noted above, the formulation core of progressive planning is to take appropriate feedback measures to deal with mutations inside or outside of the system, and the author divides the mutations of urban system into two types (Table I) in accordance with the characteristics of it, despite mutations in urban system usually presents complex dynamic process that two kinds of mutations work simultaneously, there is still some

practical significance in response to mutations to clarify their respective working mechanisms and corresponding measures:

TABLE I  
URBAN SYSTEM MUTATION AND THE MAIN COUNTER MEASURES

mutation type	endogenous mutations of urban system	mutations caused by external system effect	
		Stimulate gradually strengthened	Intense stimulation
examples	the promulgation of "Urban Planning Law"(the mutation of political sub-system)	multinational companies increase investment in China	big events happen in urban (Olympic Games in Beijing, Shanghai expo, etc)
The main mechanism of action	Interaction between subsystems, parts of subsystems mutate in the evolutionary process	External factors involve in system recycle and action strength gradually strengthen, the system mutate in competition	Fierce external factors
Planning countermeasures	Learn from rules and experience of urban system development	The initial dynamic monitor in external factors	Rapid modification, adjustment and feedback to planning compilation

#### Mutations Caused by Inner System

With the strengthening interaction between subsystems inside of urban system, system optimizes and evolves gradually. In this process, parts of the subsystems perform continuing evolution; and another parts of the subsystems exhibit mutation characteristics, which in turn have a dramatic impact on the overall urban system. For instance, under normal circumstances, the whole development of city economic showed a process of continue development, and obviously the guiding role of policy plays an extremely important role in it. With economic develops to a new stage, in order to meet the needs of a new phase, there will be new policy carried out. In this process, the urban economic system exhibits characteristics of continuous, while the political system shows the characteristics of mutation (mandatory and top-down institutional change), with regard to the space system (the focal point of urban planning formulation), is the external appearance of the relationship evolution between the economic and the political system. Reasonable industrial space layout can better promote economic development and transformations, on the contrary, unreasonable industrial space layout will hinder the evolution of the economic system. To deal with this type of mutation, we can study on urban development mechanism (typically in the experience of other countries, city experience who is on a similar developing stage) to enhance the adaptability of planning formulation. For example, when some indicators are in the region of mutation thresholds and the urban develops fast, planners should make a pre-judgment of the mutations that may occur in the future, and make corresponding adjustments in formulation ideas to reduce planning failure that caused by the adopt of steady developed planning formulation strategies, which also explains why planners should have a certain political sensitivity.

#### Mutations Caused by External System Effect

Urban system is in a dynamic process that is constantly interacting with external parts, the external factors mutated the system by involved in the hypercycle structure reaction of it. Mutation is mainly manifests in two categories: one is the gradual strengthening of external stimuli that lead to the mutation of the system, when planning formulation in face of such mutations, it can enhance the adaptability of planning by dynamic monitoring to the external conditions and studying on the acting law between the systems, as related scholars [13] have already begun to research the impaction that foreign

capital has on China's real estate market; another is the systematic mutation that severe external stimuli caused, such as large events occur in urban development, which brought dramatic changes in urban system. It is needed to start an immediate feedback mechanism to deal with this kind of mutations, seize the opportunities brought by big events and finally promote the development of the system. But here we have to note that the big events should regard as a comparison concept, for cities of different sizes, the definition of big events are not the same, therefore the specific judgments should be based on city development stage.

#### From the Management Control to the Feedback of Dynamic Monitoring

In the current rapidly changing in interests patterns of urban space, the original index-control-oriented planning and management model has been gradually emerging out of its unsuitability. Mainly reflected in which planning related departments is not sensible to perceive demand, management model is too rigid and so on, these problems lead to greatly reduced of planning timeliness. In order to reflect the complex game process under the representation of urban construction space, we need to establish a corresponding technical platform to carry out dynamic monitoring feedback of urban space. Using new technologies like GIS spatial analysis, geography and planning management decision supporting system to establish a space surveillance platform based on the principal contradiction security relationships of the current urban development stage (e.g.: city in ecologically sensitive zones can establish security relationship based on ecological protection – economic development - space pattern; city of developed areas with rapid development can establish security relationship based on economic development - social justice - spatial pattern). When mutations in the urban subsystems occur (such as new policies carries out, the occurrence of big event outside the system), after manual input of the new spatial interests safeguard relationship, the background of the platform should base on the safeguard relationship to automatically calculated and divided reasonable urban spatial interests patterns which took planning unit as the basic unit, and periodic indicators of specific plots should be set by planners under the consideration of the overall planning formulation balance. Therefore, this platform can be an effective basis for planning formulation and management, and then to solve the current reality inadaptability of planning management.

### III. CONCLUSION

With the continuous development of science, people's understanding of the complexity of urban system is also deepening. Western experience has revealed that "the rational comprehensive planning concept" exist the inadaptability to reality [14]. When facing the increasingly fierce international competition and the accelerating transition of economy and society to get rid of the middle-income trap, thoughts for urban planning formulation should be more comprehensive and flexible when facing the increasingly complex urban area and responding to the demands of various contradictory relationship stakeholders in real life, which is helpful to comprehensive, coordinated and sustainable economic and social development.

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### REFERENCES

- [1] Bertalanffy (writer), Wu xiaojiang (translator), "Life issues," Commercial Press, 1994.
- [2] Miao dongsheng, "Review of Qian xuesen complexity," Journal of Xi'an Jiaotong University (Social Sciences), pp.67-71, Apr.2004.
- [3] Zhou ganzhi, "The city and its region - a typical open complex giant system," Urban planning, pp.7-8, Feb.2002.
- [4] Cheng kaiming, Chen yufeng, "Studying progress and the review in domestic and foreign city self-organization," Urban Problems, pp.21-27, Jul.2006.
- [5] Cai hua, "evolution development research of city system in heilongjiang province based on the theory of self-organization," Harbin Engineering University, 2006.
- [6] Manfred Eigen (writer), Zeng guoping, Shen xiaofeng (translator), "Hypercycle," Shanghai Translation Publishing House, 1990.
- [7] shen xiaofeng, Zeng guoping, "philosophical problems on hypercycle theory," Social Science of China, pp.185-194, Apr.1989.
- [8] Zheng feng, "Self-organization theory revelation to the development of urban geography," Economic Geography, pp.651-654, Jun.2002
- [9] Arnold, V.I.(writer), Zhou yanhua (translator), "catastrophe theory," Higher Education Press, 1990.
- [10] Li houqiang, "Philosophical thinking on fractal theory," Studies in Dialectics of Nature, pp. 29-34, Apr.1993.
- [11] Chen qunyuan, Song yuxiang, "The coordination mechanism and coordination model of China's urban agglomeration," Journal of the graduate school of the Chinese academy of sciences, pp.356-363, Mar.2010.
- [12] Yu hong, Wu zhiqiang, "Lindblom and Gradual decision theory," Foreign urban planning, pp. 39-41, Feb.2000.
- [13] Li yanhong, Zhang tieqiang, "The influence and the counter measures of foreign capital flowing into China's real estate market," Shanghai Finance, pp.90-92, Jan.2009.
- [14] Zhou lan, "The enlightenment of western urban planning theory development for China," Foreign urban planning, pp.34-37, Jan.2001.