

# *The Structural Model and Complexity Analysis of the Higher Education Resource Supply Side System*

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**Abstract**—To define the supply structure of higher education resources is good for promoting development of higher education. The supply structure of higher education resources is the complex system with multiple purposes, multiple elements, multiple levels and multiple functions. This paper firstly defined the connotations of the higher education resource supply side, then analyzed the objectives, elements, structures, functions, environment and subsystems of this system, and discussed the cooperativity, nonlinearity, adaptability, emergence, chaos characteristic and self-organization of the higher education resource supply side by combining with the structural model.

**Keywords**—Higher Education Resources, Supply Side, Structural Model, Complexity

## I. INTRODUCTION

President Xi Jinping has repeatedly raised and emphasized at several meetings that "supply-side structural reform should be strengthened". Nowadays, higher education resources act as an important role in developing higher education, which influences the development of countries and individuals indirectly. The supply of higher education resources is not simple addition of resources supply capacity in each universities. There are always unbalanced between higher education resources (HER) on society and demand of HER. As a result, plenty of problems appear such as insufficient, single supply subject, supply lag and demand dislocation. Only when to find which factors influence HER to adjust higher education resources supply side system (HERSSS) and enhance the higher education.

Liu has analyzed four types of higher education investment modes in OECD countries, pointed out that the nation should ensure the growth of total investment of higher education, meanwhile, pay attention to the role of social investment [1]. Na has analyzed the integration of HER of Heilongjiang province with using DEA method from technical effectiveness and scale effectiveness of the integration [2]. He shuxia has built a comprehensive HERSS from five dimensions: market, government, school, social group and individual [3]. Asha K&Balasubramanian K discussed the development and use of open education resources and how to expand the HER and improve the quality of HER [4]. P. Iatarola&L. Stiefel analyzed the equity management of the investment and yielding of teacher resources and performance [5].

In a brief, study on HERSSS, scholars mostly analyzed from the aspects of supply sufficiency, supply fairness and supply

efficiency, which lays a theoretical foundation for research on HER. However, the literature on supply side research of HER combined with complex system theory is still very few. HERSSS is a complex system with diversified subject, complex relationship and hierarchical structure which has many influencing factors, belonging to multivariable complex system. By Using the complex system theory to analyze the HERSSS and try to put forward some Suggestions from the breadth, depth, speed and synergy of supply, resulting in theoretical significance and practical value.

## II. THE STRUCTURAL MODEL AND COMPLEXITY ANALYSIS OF THE HIGHER EDUCATION RESOURCE SUPPLY SIDE SYSTEM

### A. Connotation Analysis of the Higher Education Resource Supply Side System

The purpose of the education is to promote socioeconomic development. Educational resources refer to available resources for the education from the educational economic perspective, including educators and educatees, manpower, material resources and financial resources that provide the corresponding guarantee for education activities. The higher education resources refer to integration of various resources to improve human capital or value of educatees organized by higher education organizations for the higher education activity career.

Demand and supply are a pair of conceptual frameworks in economics. If demand and supply are assimilating with two sides of coins, controlling economy in demand side determines the short-term performance, while supply side determines the long-term development of economy. In this thesis, the connotation of the supply side is explained as: changing the economic development mode, adjusting the economic structure, improving the total factor productivity, and focusing on the structural reform in promotion system, mechanism and technology with a point of view on supply side.

To sum up, by combining with the systematic thinking, the author thinks that higher education resource supply side is involved in participation of multiple subjects and multi-layered interaction. It is the dynamic and non-linear complex system with the target of adjusting the supply structure of higher education resources, so as to solve a series of problems, including demand-supply dislocation, single supply subjects, and unbalanced resource distribution, so as to promote the continuous sound development of Chinese higher education. In this thesis, the author analyzes the study on the influence factors

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of higher education resource supply side from the subsystem and external environment.

*B. The System Analysis of the Higher Education Resource Supply Side*

Bertalanffy thinks that the system is the “complex of multiple elements with interaction”. He definitely proposed the “task of the general system theory as determining the general rule that is suitable for the system”, so as to explore the general characteristics of the system, including integrality, relevance, dynamics, orderness and purposiveness. In this thesis, according to scientific principle of the system, by concluding, summarizing and generalizing various common characteristics of the general system, the system is defined as: the integration composed of subsystem that constantly conducts substance, energy and information exchange with environment. Two subsystems above are relatively independent and mutually associated and affects each other with the specific target, function and structure. As mentioned above, the higher education resource supply side system has the features of general system. It can be considered as a system. It is totally feasible and extremely significant to use the systematic principle to analyze relevant issues of the higher education resources. As a result, the system composition of the higher education resource supply side is shown as follows:

1) *The objectives of the higher education resource supply side system:* In this thesis, the author thinks that the objectives of the higher education resource supply side system should follow up with the steps of Xi Jinping’s new era, greatly promote the structural reform of education supply side, solve a structural problem of the higher education resource supply side (the dislocation problem of supply and demand in higher education resources, the equity issue of higher education and unbalanced distribution of higher education resources), and promote continuous sound development of Chinese higher education.

2) *The elements of the higher education resource supply side system:* The element is the basic unit of constituting in the system and it is the abstract summary for the constituent part or individual of the system. The elements of the higher education resource supply side system include the supply subject, mechanism, tangible resources and intangible resources. Among which, mechanism is involved in incentive mechanism, guarantee mechanism and supervision mechanism. Incentive mechanism includes the spiritual motivation and material motivation; guarantee mechanism contains the organizational guarantee and institutional guarantee; supervision mechanism gets involved in horizontal supervision and longitudinal supervision.

3) *The subsystems of the higher education resource supply side system:* The scientific system theory thinks that the subsystem refers to the system with certain function. It is composed of multiple elements. According to its objectives, the higher education resource supply side system(as shown in Fig. 1) is divided into the subject subsystem of supply side, mechanism subsystem of supply side, content subsystem of

supply side, and effective evaluation subsystem of supply side, as follows:

a) *The subject subsystem of the higher education resource supply side:* The supply subject subsystem refers to the subject system that can provide resources for higher education, including the governments, colleges, society(including enterprises and other social groups) and individuals(including educatees and their families). They play a decisive effect on promoting the development of higher education resources.

b) *The mechanism subsystem of the higher education resource supply side:* The supply mechanism subsystem refers to the incentive, guarantee and supervision system that can provide resources for higher education, including incentive mechanism, guarantee mechanism, and supervision mechanism. Incentive mechanism includes spiritual motivation element and material motivation element. The guarantee mechanism contains the institutional guarantee element and organizational guarantee element. The supervision mechanism has the governmental supervision element, market supervision element and college supervision element. They develop an important role on promoting the supply development of higher education resources.

c) *The content subsystem of the higher education resource supply side:* The content subsystem refers to the content system that can provide resources for higher education, including tangible resources and intangible resources. Tangible resources contain the manpower resource element, material resource element and financial resource element. Intangible resources include the cultural element, information element, technical element, and scientific product element.

d) *The effect evaluation subsystem of the higher education resource supply side:* The evaluation subsystem refers to the system that can evaluate resources for higher education. The evaluation subsystem evaluates it from the supply width, supply depth, supply effectiveness and supply synergy degree.

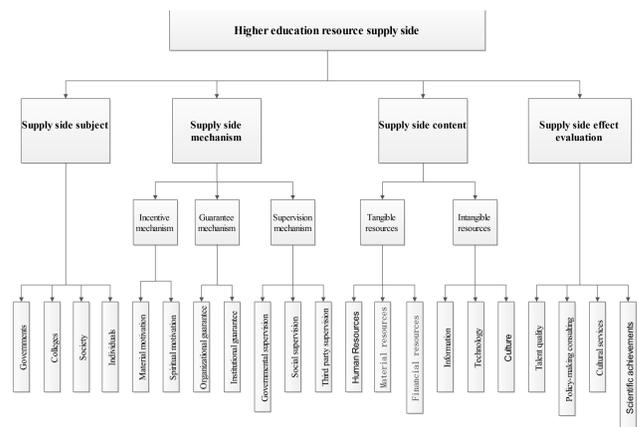


Fig. 1. The higher education resource supply side system

4) *The functions of the higher education resource supply side system:* The higher education resource supply side system

is the subsystem of the higher education. Its functions are endowed with the specific demands. In other words, it completely and comprehensively realizes the social talents and provides high-quality scientific products, makes a decision of high level, and offers advanced cultural services.

5) *The structure of the higher education resource supply side:* The sum of correlation between elements becomes the system structure. The generation and development of the higher education resource supply side are conducted in certain time space. Governments, colleges and society(including enterprises and social groups) and individuals(including educatees and their families) affect the higher education resource supply side in specific time and space. Meanwhile, elements and environment refer to some rules and interaction, so as to constitute in the system structure.

6) *The environment of the higher education resource supply side system:* The set of associated things out of the higher education resource supply side system constitutes in the system environment. In this thesis, external social politics, economy, culture and scientific environment are defined as the external environment of the higher education resource supply side system.

C. *The Structural Model of the Higher Education Resource Supply Side System*

The higher education resource supply side system has the programmed hierarchical structure. The specific contact information between internal elements forms the characteristic hierarchical structure. The characteristic contact information forms the specific special system—the higher education resource supply side system(as shown in Fig. 2).

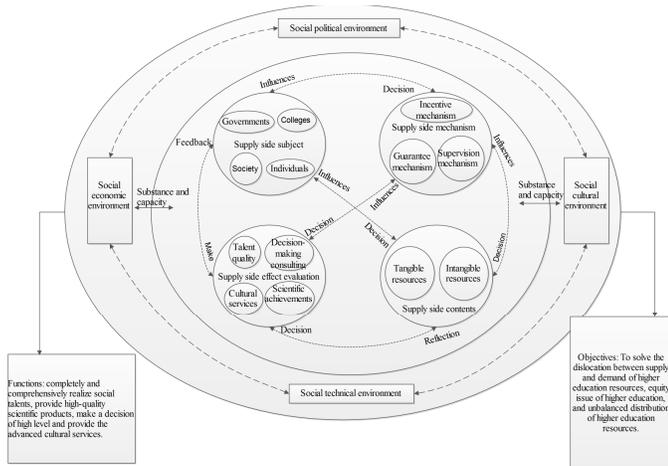


Fig. 2. The structural model of the higher education resource supply side system

III. THE COMPLEXITY ANALYSIS OF THE HIGHER EDUCATION RESOURCE SUPPLY SIDE SYSTEM

It can be observed from the above two parts, in addition to the integrality, purposiveness, hierarchy, openness, and stability of general system, the higher education resource supply system also has the nonlinearity, adaptation, chaos characteristic and

emergence of the complex system. As a result, the author analyzes the complicated characteristics of the higher education resource supply side system.

A. *The Synergy Analysis of the Higher Education Resource Supply Side System*

The synergy is involved in the system of multiple subsystems. When subsystems coordinate with each other to generate the synergy and mutual effect, the system will stay in the self-organizational state. When external control parameter is changed in a critical point, internal subsystems in the system will take the corporate action to form the correlative synergy, thus the system realizes the transformation from disorder to orderness. The synergy between subsystems is the key to change the system and has no direct relationship with the equilibrium state or non-equilibrium state of the system, near-equilibrium state or far-equilibrium state of the system.

The higher education resource supply side system has numerous subjects and the complicated relationship. In order to greatly develop the system functions, it needs the collaborative promotion of each party. For example, synergy between supply side subjects(governments, colleges, society and individual) and subsystems enables the system to spontaneously form the order structure in each period, region and function of higher education supply resources, so as to promote the development of system synergy. The management synergy of higher education resources affects the supply effect and system function. By improving the mutual cooperation, association and collaboration of the higher education resource supply side subjects, behavioral and functional optimization of the higher education resource supply side system can be realized. In the process that the higher education provides resources, it not only develops the macro-control role of the government, analyzes its causes, proposes the systematic and comprehensive scheme, policy and measures, but also develops the leading and guiding role of the market and colleges in the higher education resource supply side system.

B. *The Non-linear Analysis of the Higher Education Resource Supply Side System*

Nonlinearity means that all elements don't refer to the simple overlapping. The system entirety is greater than the sum of elements. Individuals can't replace the entirety. The local hierarchical structure can't state the entirety. In addition, the discipline between levels can't be mutually replaced and explained. Elements and hierarchical structures affect and constrain each other and have the complicated non-linear interaction. Relative to linearity, nonlinearity is the result of synergy between internal elements[6]. In other words, nonlinear is the necessary condition for complexity. The complex system is the nonlinear dynamic system.

Higher education resource supply side system is the complex system. The overall role must be greater than the sum of elements. Each element and each subsystem in the system are correlated and mutually restricted. In the complex system of the higher education resource supply side system, governments, society and individuals provide higher education resources for colleges. The governments utilize the institutional guarantee mechanism to provide financial resources of higher education. The society and individuals offer the corresponding information element and technical elements through material motivation and

organizational guarantee. Colleges organize and guarantee the international teaching personnel and administrative staff to realize supply of manpower, substance, culture and scientific resources in higher education. The sufficiency and equity of resource supply can't be separated from the governmental supervision and market regulation. Through a series of procedural operation, colleges output talents to the society, make a decision, and provide the advanced culture and scientific achievements, so as to achieve the functions of higher education resources. At last, through the feedback elements, it reports reasonability and fairness of resource supply side to governments, colleges, society and individuals and whether there are problems, so as to readjust the supply side structure.

### *C. Adaptation Analysis of the Higher Education Resource Supply Side System*

The so-called adaption means that it can conduct the interaction with environment and other subjects. Subjects constantly "learn" or "accumulate experience" in the continuous interactive process and change their structure and behavioral mode according to the experience[7]. Holland(USA) proposed the core idea of the complex adaptive system(CAD), which means that the adaption creates the complexity. As a result, adaption is the precondition and necessary condition of the complex system. the complex adaptive system generally has 4 characteristics: one is based on the adaptive subject, namely the adaptive subject has the perceptive and adaptive capacity. It has the purposiveness, initiative and positive "activity", can conduct interaction with other subjects at random, automatically adjust their state to adapt to the environment, cooperate or compete with other subjects, strive for the maximal survival and continue the self-benefit. Secondly, it refers to co-evolution. In other words, subjects not only conduct the evolution from the uniform form of diversity to the uniform form of the other one. Moreover, each subject is evolved together. Thirdly, co-evolution tends to the chaotic margin. That is to say, various elements in the system never stand still in a state, while it never roils to disassemble. Fourthly, it generates the emergence phenomenon. This phenomenon is the most essential characteristic, developing from being small to be big and from simpleness to complication. In the emergence process, even if the discipline is not changed, the thing determined by the discipline is changed for this reason. Therefore, there are lots of the structures and modes that are constantly generated. These structures and modes not only have dynamics, but also have hierarchy [8].

The higher education resource supply side system is the integrity composed of supply subjects at all levels, various supply mechanisms and various supply resources which are mutually associated and restrained. From the connotations of higher education resource supply side system and historical evolution history of the higher education resources in each country, the higher education resource supply side system is the complex adaptive system. First of all, the subjects of the supply side system(governments, society, colleges and individuals) have the initiative and adaption. They greatly adapt to the environment by adjusting their structure and behavioral mode in the interaction with the external political environment, economic environment, scientific environment and cultural environment, so as to survive. Besides, from the historical

evolution process of higher education resource supply side system.

The mutual influence of social-economic environment, political environment, technical environment and cultural environment with higher education resource supply side subjects is the power fountain to constantly evolve and make progress for higher education resource supply side system in its historical development process. At last, the mutual influence of higher education resource supply subjects with the external environment is constantly evolved and forms the different levels and structures. For example, with the changeable development of the society, the resource center of the higher education is correspondingly changing. It turns to give priority to supply from the demand-oriented mode. And then, it turns to the adjustment of supply-demand structure. The supply system mode of higher education resources is gradually developed into the higher education resource supply system mode of multiple subjects (governments, society, colleges and individuals) and flexible and effective learning forms from the single supply form of colleges or governments[9]. Moreover, due to objective existence of differences, the structure of the higher education resource supply side system in each country is present in the diversity.

### *D. The Emergence Analysis of the Higher Education Resource Supply Side System*

The emergence of the complex system means that when the individuals in the system abide by the simple rules and form the integrity in the interaction of each part, some new attributes or rules will suddenly show up in the system level. Emergence won't destroy individual rules, but it can't be used to explain emergence, namely the system integrity is greater than the sum of parts.

No single element in the higher education resource supply side system owns the complicated functions. For example, in the subject subsystem, since the public goods attributes of the higher education are weak, so higher education is the quasi-supply goods between pure public objects and private objects. As a result, the supply subjects of higher education resources should include the governments, colleges, society and individuals. The synergy between supply subjects forms the all-round multi-dimensional education resource supply system. The construction of the "partnership" is good for realizing the complementary advantages and value-added efficiency of higher education resources, improving supply quality and quantity of higher education resources, and safeguarding the sound and rapid development of higher education. However, no aspect can be attributed to the single supply subject. Besides, the new function and results emerged by the higher education resource system and any subsystem also reveal the emergence of the complex system.

### *E. Chaos Characteristic Analysis of the Higher Education Resource Supply Side System*

Chaos is not a random and occasional event. It is the ubiquity of macro systems and micro systems in the universe. Anything has chaos. The so-called chaos characteristic refers to the essence to arrange the qualitative thinking and quantitative analysis. It is used to explore the overall and continuous dynamic data relationship, instead of using the single data

relationship to explain and predict behaviors. The original state of all things looks like the irrelevant debris. When chaos comes to an end, the inorganic debris will gather into the integrity organically. Considering that the subjects of higher education resources are people in dynamic changes, while the higher education resource supply always observes certain discipline to interact with people in the historical evolution process, thus it conforms to the framework of chaotic theory in the complex system. According to the chaotic theory of the complex system, higher education resource supply side system will generate the unexpected good or bad results. No matter what it is, the research on the higher education resource supply side system should be persistent. Only to accumulate the useful data can it look for the discipline and increase the predictability of the supply effect and enhance the supply effect. Besides, the chaotic characteristic of the higher education resource supply side system not only admits the long-term existence of the system's aperiodic motion, but also admits the internal randomness in the system. In the supply process of higher education resources, governments, society, colleges and individuals generate the aperiodic changes under the influences of special factors and divisors. For example, the supply situation of higher education resources in a stage and period is greatly changed. Economic development and governmental policy in some areas generate the absorptive effect. Some colleges cause the butterfly effect through the successful cases of university-industry cooperation and political-educational industry integration. As for the chaotic phenomena generated by the system, we exactly know that it fails to do long-term prediction effectively. Instead, it only can foresee in advance from some aspects, guide and restrain its development through feedback and non-feedback control methods, and drive it to play a role.

#### *F. Self-organization Analysis of the Higher Education Resource Supply Side System*

Under the complicated nonlinear role of each factor, rise of far equilibrium state in internal elements of the open system may be amplified, so that the system spontaneously organizes without the specific external intervention. In this way, the system realizes the development from disorder to orderness and from low level to high level. In a word, self-organization of the system turns into another order organization state from an organizational state spontaneously. It is worth noting that the self-organization of the system doesn't mean that the system exists independently after leaving the interaction with the environment. Self-organization and other-organization have the relationship of dialectical unity.

Self-organize is reflected in the self-creation, self-growth, self-replication and self-adaption in the higher education resource supply side system. Self-creation constantly creates the new major and course and creates the professionals in the new major and industry by combining with social development demands in colleges. Self-growth means that individuals improve self-quality and ability to gain resources in the higher education resource supply side system. In self-replication, colleges, society and individuals will promote and copy the good experience, measures and practice from the supply aspect of the higher education resources, so that colleges in the higher education resource supply side system can fully study, imitate and propagandize. Furthermore, as for self-adaption of the

system, participants of the higher education resource supply side system should generate the self-adaptive ability for various environmental changes brought by the social economic status and national development situation and conduct self-analysis and optimization treatment for various problems and difficulties in different periods and stages of employment management through the governmental feedback control, so as to promote stable, dynamic and order development of higher education.

#### IV. SYNERGISTIC MEASURES OF THE HIGHER EDUCATION RESOURCE SUPPLY SIDE SYSTEM

In order to improve the supply validity of the higher education resources, the author proposed four countermeasures on perfecting the higher education resource supply side from width, supply depth, supply speed and supply synergy:

- Expand the width of the higher education resource supply side system, enlarge the supply channels of resources, construct the supply subjects of diversity, and solve the issue of single supply subject;
- Explore the depth of the higher education resource supply side system, make innovations on the supply contents and supply structure, expand the supply depth, and solve the problem of insufficient supply resources;
- Accelerate the speed of the higher education resource supply side system, improve the resource allocation capacity of the government, improve the guarantee speed, and solve the problem of lagging supply;
- Balance the synergy of the higher education resource supply side system, improve employment rate of colleges, satisfy enterprises' demands for talents, and solve the problem of supply-demand dislocation.

#### V. CONCLUSIONS

In a brief, the supply side system on higher educational resource is composed of the interdependence and interaction of several factors includes tangible and intangible resources provided by the government, universities, society and individuals for higher education through spiritual incentive, material incentive, institutional guarantee, organization guarantee and supervision mechanism on lateral and longitude supervision mechanism. In addition, the supply side system on higher educational resources constantly exchanges material, energy and information with the external social and political environment, social and economic environment, social science and technology environment, social and cultural environment. As a result, it is a complex system with multiple functions such as specific functions, cooperativity, nonlinearity, adaptability, emergence, chaos and self-organization.

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