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Analyzing the Comprehensive National Science Center in China: From A Perspective of Complex Innovation System

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Abstract
The current study comprehensively investigated the emerging topic on the comprehensive national science center (CNSC) in China. Drawing on the innovation system theory, we proposed that CNSC is a new complex innovation system. Specifically, we investigated its characteristics, systematic components, and structural relations from a systematic perspective. Our analyses showed that CNSC has several system characteristics including platform factor, resource factor, subjective factor, service factor, and environment factor. Moreover, we suggested that the development of CNSC can facilitate the establishment of an innovation subject system (including knowledge innovation system, technology innovation system, and innovation diffusion system) and an innovation support system (including management operating system, resource support system, and environment support system). The current study contributes to the growing research on CNSC by providing a clear and complete picture of why, how and when it works within the innovation system. The results provide a reference to the government and other participants in regard to clearly recognizing and effectively managing CNSC in China.
Keywords: CNSC, Innovation Systems, Systematic Study

1. Introduction

With the development of the revolution in science and technology, China is increasingly engaged in global competitions to gain the national competence. Thus, the Chinese government has initiated a series of actions to build the innovativeness in the science and technology areas. Specifically, in 2016, the Outline of the National Strategy for Innovation-Driven Development was launched, which highlights the critical role of innovation to enable the realization of a major scientific nation by 2050 through stimulating innovation activities. Statistics from Ministry of Science and Technology of the People's Republic of China further show that the R&D spending in China reached 1.76 trillion Yuan in 2017, accounting for 2.15 percent of GDP, which is higher than the average level in the fifteen European Union countries. Although these evidence effectively showed that the innovation-driven strategy in China has achieved remarkable outputs in recent years, the innovation capacity of China is still insufficient compared to countries with advanced science and technology innovation. Therefore, China recently is reinforcing the constructions of science centers in Zhangjiang, Hefei, and Huairou—that is, the CNSC (CNSC) which targets on accelerating the national innovation system.

Given the significance of national science center in the development of science and technology innovation, scholars have investigated this topic in a broad range, including concepts, functions, and developments. Specifically, Wang (2016) initiatively defined the CNSC as "a large open research and development base with cross-type, frontier basic science research, major technology research and development and promotion of technology industrialization, which is established with the approval of national legal procedures and relying on the advanced major science and technology infrastructure group" (p.25). Zhang (2017) suggests that reflecting the innovation development strategies nationally and regionally, CNSC is a systematic integration of Government-Industry-University-Institute of innovation actors and multiple infrastructures. Song (2017) from the functional perspective argues that CNSC integrates multiples strategic functions, including the international first-class scientific research base, the national innovation talent base, the national think-tank, and the national science, technology and finance driver. To establish the development of CNSC, some researchers have provided insightful suggestions. Specifically, Zhang (2018) highlighting the internationalization of innovation claims that the in-depth integration of scientific and technology relies on researchers' engagements into the global network of scientific and technological innovative activities through building a leading and international scientific infrastructure. With regarding to the talents construction, scholars suggest that autonomy and finical supports should be provided to enable team members' interactions in order to promote the interdisciplinary collaborations.

However, considering the emergence of research in initiating CNSC, the existing findings in this regard are limited. To be specific, few research has been conducted to investigate CNSC from the perspective of the system, including lacking of knowledge on conceptualizations, functional elements, and operation mechanism. This research gap significantly limits the possibilities of building the innovation capabilities and utilizing the outputs of innovation, which in turn weakens the developments of innovation system. Therefore, comprehensively examining the definitions, structures, and functions of CNSC is both timely and necessary. In the present study, we drawn on the innovation system theory to treat CNSC as a new complex innovation system, and investigate its characteristics, systematic components, and structural relations from a systematic perspective. In doing so, we aim to contribute to the growing research on CNSC by providing a clear and complete picture of why, how and when it works within the innovation system.

2. Theoretical Review

The development of innovation research originated from Schumpeter's work in the early 20th century. With the development of innovation models (e.g., linear model, link interaction model, and vendor-centric model), Jill proposed the systematic nature of innovation and initiated the "system research paradigm"(Wei et al. 2017). Consistently, research in the innovation system develops rapidly, including multiple perspective (e.g., the regional innovation system research stream, and the industrial innovation system research stream).

2.1 National Innovation System

The national innovation system considers the geographical and administrative boundaries to examine the impact of national economy and policies on the processes of technological innovation and diffusion. Based on the research line of the Japanese innovation system, Freeman initiatively defined the national innovation system as "a network of institutions in the public and private sectors where new technologies are introduced, stimulated, changed and spread through their activities and interactions" in 1987 (Malcolm, 2010). Along this line of arguing, Nelson (1993) further defined the national innovation system as "the overall institutional arrangement which determines the innovation performance of a national enterprise through interactions". In the framework of national innovation system, innovation is not an independent process, but a systematic project that requires the interaction of multiple innovation subjects, and takes innovation as a key driving force for the national reform and development.

2.2 Regional Innovation System

As regional economy is increasingly becoming a focus of global economic activities, research in the regional innovation system area has increasingly received scholarly attention. Specifically, in Cooke's (1992) work, he conceptually defined the regional innovation system as "an organizational innovative system composed of enterprises, research institutions, and higher education institutions with inter-division and correlation within the region." (p.366). Kaufmann et al. (2000) concluded regional innovation systems into three types through comparative analyses of six regions of the European Union: enterprise basic innovation system, scientific basic innovation system, and policy basic innovation system. Chung (2002) stressed the "top-down" constructive characteristics of the innovation system. Specifically, the regional innovation system belongs to the national innovation system, and the regional innovation system is an effective method to build the national innovation system. Furthermore, some Chinese scholars enriched this line of research by taking the Chinese context into consideration. For example, Guan et al. (2005) suggested that regional innovation system is a complex network system that transfers innovation input into innovation output. Similarly, Wei et al. (2017) reported that the regional innovation system is a social system formed by the interactions of different innovation subjects in a certain regional space.

2.3 Industrial Innovation System

Some scholars suggest that the boundary of innovation system is not limited by the fixed geographical characteristics. That is, the traditional geographic perspective of defining the national innovation system and regional innovation system has limitations to explain the influences of innovation system. Therefore, they propose the utilizations of the concept of industrial innovation system. Specifically, Malerba (2009) pointed out that the industrial innovation system is a network formed by the participants who develop, produce and sell the products of a specific sector. The advantage of the industrial innovation system lies in a better understanding the boundary of the industrial sector. Distinguished from national innovation system and regional innovation system, industrial innovation system highlights that the relationship between enterprises and organizations is primarily based on technological innovation, which originates from the interdependence with technology. Therefore, dynamic coordination of technological development and intra-industry technology flow become increasingly important.

2.4 Innovative System Structure

System structure is one of the core elements in the innovation system research. Researchers have devoted considerable attention to identifying the nature of the structures. Following the structural model of innovation system proposed by Asheim et al. (1997), Autio (1998) developed a "dual system model". This theoretical model suggests that regional innovation system primarily consists of the subsystems of knowledge generation, development, application, and diffusion. Cooke (2002) studied the regional innovation system in eleven European regions and proposed that the innovation system was composed of external factors such as knowledge application and development subsystem, knowledge generation and diffusion subsystem, regional socio-economic and cultural foundation. Wei (2007) proposed an industrial cluster innovation structure model and a multi-level innovation system architecture, including three levels of subsystems (e.g., core network system, auxiliary network system and peripheral network system).

3. Analyses of Systematic Characteristics of CNSC

3.1 Systematic Connotation of CNSC

According to the innovative systematic analyses of CNSC, there are three basic arguments can be provided. First, CNSC is an innovation system containing various innovative elements where these innovation-oriented goals are interacting in a systematic towards the realizations of scientific and technological innovation. Second, as a subsystem of the national innovation system, CNSC is organized by the state and promotes the realization of national innovation strategy in coordination with other subsystems. Third, CNSC has the characteristics of both regional innovation system and industrial innovation system; that is, it is characterized as openness within a network which not only functions as a systematic arrangement within a certain region, but also acts as an innovative link in multiple industrial fields. However, due to a greater difference among CNSC, the national innovation system, and other subsystems, CNSC emphasizes its core mission of scientific innovation. Consequently, there are serval distinguished specialties in CNSC. To be specific, the basic principles of the distributions are relying on academic institutions, high level of discipline constructions, and high-level innovative talents; the domains reflect the national ideology, missions, and requirements; the activities include the basic and international cutting-edge interdisciplinary research; and the outputs target on the originality and transformative technologies.

To sum up, from the perspective of innovative system, CNSC can be defined as a large open innovation system where multiple innovators (e.g., governments, colleges and universities, research institutions, enterprises, and human capital) conduct scientific and technological innovative actions. As a core driving force of state and regional economic development, CNSC is based on the infrastructures of science and technology.

3.2 Systematic Characteristics of CNSC

3.2.1 Integration and Complexity

In regard with the innovative elements, CNSC contains many innovative elements, such as large scientific installations, innovative talents, scientific and technological innovation institutions, and policy resources. From the perspective of main actors of innovation, CNSC is a group of the state and local government agencies, research institutions, institutions of innovative and cutting-edge research, innovation transformation platforms, intermediary agencies, financial institutions, and other actors in the innovation processes. All these different actors play different roles in the center. Moreover, CNSC is composed of the subsystems of knowledge innovation, technology innovation, industry innovation and policy innovation; therefore, it characterizes as integration and complexity. Specifically, the main systems, subsystems, innovation subjects, as well as innovation elements are continuously exchanging the knowledge, materials, energy and information with the external economic environment, population environment and social environment. This complexity exerts a diverse and nonlinear effects. Finally, there are many factors potentially influencing the systematic evolution of CNSC which are interwoven and integrated with each other. The forms of action are complex and changeful, and the complexity increases sharply with the disturbance of various random factors, nonlinear factors and fuzzy factors.

3.2.2 Openness and Dynamics

CNSC is a typical dissipative structure system with the characteristics of openness and dynamic. Instead of existing in isolation, CNSC constantly introduces such innovative resources as talents, capital, information and technology from the outside of the system. Through the external cooperation of innovation subjects, CNSC generates the negative entropy flow within the system. This process definitely drives the evolution of the system. At the same time, the positive entropy flow within the system is exported to the outside through innovative diffusion, transferring and maintaining the internal order of the system. Therefore, the CNSC is typically an open system. Additionally, the comprehensive national center for science in the construction and operation process can be treated as a continuous dynamic evolution process. This process is characterized by comprehensive elements, structures, and functions. Thus, the national center for science and environment is in a state of dynamic

changes—that is, each subsystem is interdependent, mutually adaptive and restrict, which makes a comprehensive evolution process of the national center for science in "dynamic balance".

3.2.3 Competitiveness and Synergy

There are competitive relationships among the subjects of CNSC. For example, the innovative subjects compete for limited resources (e.g., talents, funds, information, policies and other innovative resources) to facilitate their own development, as well as for the ownership, disposal and profit distribution process after the formation of the innovative achievements. Similarly, the competitive relationships between CNSCs and other scientific research institutions nationally and internationally can effectively enhance the innovation competitiveness, because it acts as an important endogenous driving force for the survival and development of CNSCs. At the same time, CNSC has the requirement of synergy, including external synergy and internal synergy. Specifically, these synergies are embodied in the innovation process synergy such as development orientation, innovation field, resource allocation, innovation cooperation, and achievement sharing, as well as the collaboration between the upstream and downstream of the innovation chain, the upstream and downstream of the industrial chain and the internal and external of the system. The development of collaborative innovation efficiency, thus, is the reason and purpose for the existence of CNSC. Chen and Yang (2012) suggested that scientific and technological innovation focusing on knowledge creation effectively carries out large-span innovation activities through mutual cooperation among production enterprises, government departments, research and development institutions and social organizations. As a results, scientific and technological innovation with the purpose of achieving breakthroughs in major scientific and technological areas can generate innovative synergies and innovative economic effects.

3.2.4 Self-organizing and Other-Organizing

CNSC is an innovation system constructed by national organizations. It is a special system between an artificial system and a natural system. So there are both the self-organizing phenomenon of natural system and the other-organizing function of artificial system. On the one hand, when the internal innovation elements, innovation subjects and subsystems are changing, and the external factors (e.g., economic environment, population environment and technological environment) are fluctuating, CNSC is likely to respond by self-adjustment in order to ensure the normal operations of the system. On the other hand, as the principal part of national innovation system, CNSC is inevitably influenced by the governmental policies (e.g., funding, and personnel support). Since the government construction and operation management can directly impact various aspects of CNSC (e.g., functions, and developments), CNSC has a nature of other-organizing feature.

4. Elements of CNSC

As a complex integrated system, CNSC can be classified into five categories in general: platform elements, resource elements, subjectivity elements, service elements and environmental factors. As shown in figure 1, the internal factors include platform, resource, subjectivity and service elements, while the external factors including the elements of environment.

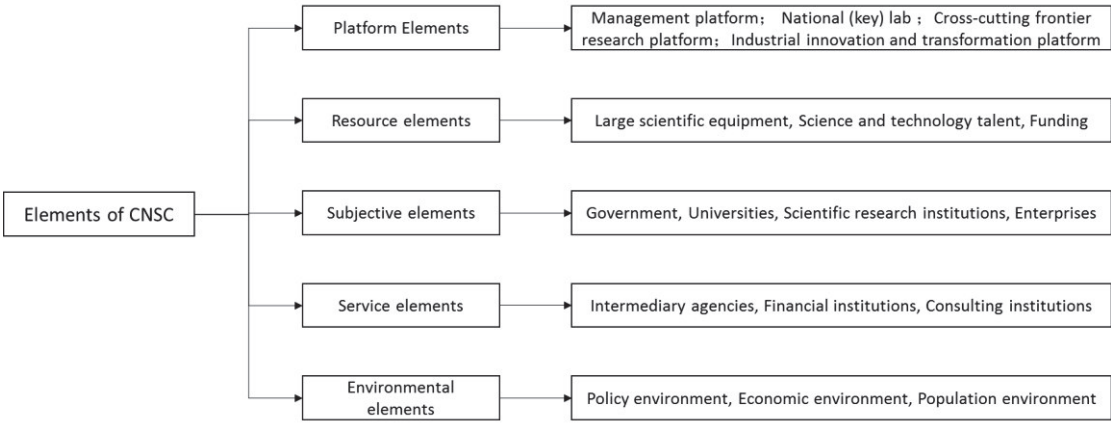

Figure 1. Element Composition of CNSC

4.1 Platform Elements

As a comprehensive nerve center of CSNS, the operation & management platform plays an important role in the process of construction and operation. It functions as making and implementing the strategies of CNSC development, mobilizing and managing innovative resources, establishing the institutional mechanisms, promoting the regional, national and internationally collaborations, and facilitating the adjustment and improvement of operation efficiency. All these functions can enhance the rights and interests of stakeholders.

The state laboratories and the state key laboratories focus on fulfilling the need of national goals and strategies. As a national science and technology innovation platforms for scientific and engineering research, these laboratories are expected to lead the future development. Among these laboratories, the national laboratories representing the national level of science and technology are not only the key drivers of innovation, but also the keeper of national security. Moreover, the state key laboratories focusing on basic research and applied basic research can gather strength in original innovation capacity.

The cross-cutting frontier research platform aims to building an interactive space for different innovation subjects, which studies and solves complex frontier problems across fields and disciplines through collaborative innovation. For example, Hefei National Laboratory for Physical Sciences at the Microscale is committed to carrying out cross-innovation based on nanotechnology, biotechnology, information technology and cognitive science.

The industrial innovation and transformation platform is a bridge connecting the innovation chain and the industry chain, as well as the scientific and technological innovation achievements and relevant industries. In doing so, the realizations of transferring and diffusions of the knowledge and technology can be achieved to boost the innovation value increment. For instance, Hefei Ionic medical center is a comprehensive deployment of the national center for science in the field of health industry innovation into one platform, through the International Thermonuclear Experimental Reactor (ITER) project, Experimental Advanced Superconducting Tokamak (EAST) device and other international top research the application of scientific and technological achievements of science and engineering in the medical industry, the development of superconducting proton therapy system and applied to the field of tumor treatment.

4.2 Resource Elements

CNSC is a collection of innovative resource elements. Among these elements, large scientific equipment and other scientific research facilities are the core material conditions for scientific research and technological innovation. In recent years, international scientific and technological competition and cooperation increasingly rely on the traction and support of major scientific and technological infrastructure. Thus, under the national scientific planning and systematic layout, Shanghai Zhangjiang CNSC has built and initiated the constructions of Shanghai light source, national protein scientific research (Shanghai) facility, soft X-ray free electron laser and other major scientific and technological infrastructures. Similarly, Hefei CNSC has four major national science and technology infrastructures: synchrotron radiation light source, all-superconducting tokamak, steady-state strong magnetic field, and key system of convertor. In addition, Hefei advanced light source (HALS) and three-dimensional comprehensive observation and simulation facility of atmospheric environment have been initiated for pre-research. Huairou CNSC in Beijing is structuring the comprehensive extreme condition experimental facilities, the earth system numerical simulation devices, the multi-modal cross-scale biomedical imaging facilities, and the second phase of the meridian projects.

Science and technology talent resources is the core of the comprehensive national center for science in scientific and technological innovation. Specifically, having abilities and knowledge, the talented people bring their potential into the innovative activities through utilizing their fruitful experience and abstract thinking. Thus, they can apply all kinds of tools or methods and new technology into products or real productive practices. This line of reasoning indicates that the quantity and quality of scientific and technological talents are not only the important measurements of national or regional innovation capacity, but also the significant foundations of developing CNSCs. Shanghai Zhangjiang CNSC is a gathering place of high-end innovative talents. Currently, there are 176 academicians of National Academy of Sciences and National Academy of Engineering.

Furthermore, the stable and abundant scientific research funds are the financial resources for the construction and operation of the CNSC. These funds are mainly used for the constructions of scientific research facilities and equipment, the purchase of experimental equipment and consumables, the provision of research office conditions, the support of domestic and international exchanges, and the protection of researchers' living expenditure and the operations of the platform. From the experience of funding allocations from the developed countries (e.g., U.S.), it is clear that governments become the main source of research institutions of scientific research funds. Take U.S. as an example, in the national laboratory affiliated by department of energy, more than 80% of research funding is from the government. The similar situation in France is that 80% of the operation funds in the Centre National de la Recherché Scientifique (CNRS) are directly received from state funding. Moreover, in the National Institute of Advanced Industrial Science and Technology (AIST) in Japan, the percentage of the funds from the government is about 80%.

4.3 Subjective Elements

The innovative subjects of the CNSC include universities, scientific research institutions, enterprises and governments. They have different resource advantages and functional positioning, which complements with each other.

Universities and scientific research institutions are the cradle of scientific and technological innovation talents cultivation.As the main position of basic research and applied basic research, they are the carrier of major scientific and technological infrastructure. Basically, they directly participate in the innovation and development of CNSC. For example, Shanghai Zhangjiang CNSC gathers high-level universities such as Fudan University, Shanghai Jiao Tong University and Shanghai Tech University, as well as scientific research institutions such as Shanghai branch of Chinese academy of sciences and Li Zhengdao research institute. Hefei CNSC is also dedicated to the construction of high-level universities and disciplines such as University of Science and Technology of China, Hefei University of Technology and Anhui University.

Acting as the maker of science and technology policies, the government plays a guiding role in the construction and operation of CNSC, as well as undertakes the function of public innovation management. Government naturally has irreplaceable advantages in mobilizing scientific and technological innovation resource and policy tool innovatively. By means of guidance, motivation, promotion, regulation, protection and coordination, the government plays different roles in the evolution of CNSCs, such as the leader and initiator in the construction stage, and the manager and servant in the operation stage. Differing from other innovation subjects, the state and local governments can bring in all kinds of innovation elements to the CNSC, apply public policies and measures to standardize and coordinate the behaviors of other innovation subjects, which in turn promotes the functional realization of CNSCs.

Enterprises are the leading force of scientific and technological innovation. Thus, they are the suppliers of market demand information, the demanders of scientific and technological innovation results, and the main bearers of industrialization. However, due to the lack of basic conditions of conducting and developing research, and scientific and technological human resources, enterprises are faced with high level of risks in the innovation processes. These factors make enterprises more subject to seeking cooperative innovation with relevant external institutions. For example, IFLYTEK is collaborating with such organizations as the speech and language processing national engineering laboratory in the University of Science and Technology of China, Language Institute in the Chinese academy of Social Sciences, Robot (Hefei) International R&D Innovation Research Institute in the Harbin Institute of Technology. These collaborations include proposing the project needs and providing scientific research funding for scientific research project, optimizing the enterprise market advantages and industrial advantages, and boosting the basic research to drive the intelligent voice industry towards upgrading innovatively.

4.4 Service Elements

Science and technology intermediary agencies can be divided into information intermediaries, technology intermediary agencies, funding agencies, personnel agency, etc.. Through connecting the science and technology resources and outputs from both the supply and demand, all kinds of innovative elements can be transferred efficiently between innovation subjects and between innovation subjects and service subjects. As a result, connections and nodes are likely to be built in the innovation networks. For example, Hefei is under constructions of building an International Talent City. It aims to comprehensively serve national center for scientific talent exchange, build a high-end talent tank (e.g., talent achievements exhibition, and business incubation and resource sharing), and develop a comprehensive service platform for government, enterprises, social organizations and professionals.

Moreover, financial institutions provide financial support for enterprises and other innovative activities through loans, equity investment and other means, especially for scientific and technological enterprises to protect their intellectual property. These activities can significantly open up the channel transferring from "knowledge base" to "capital base".

Consulting institutions such as think tanks aim to provide professional services during the process of scientific and technological innovation (e.g., decision-making consultation, management consultation, legal consultation and policy consultation, etc.), which facilitates innovation subjects to accurately position and efficiently carry out their scientific and technological innovation activities. Although the service elements above are not the innovation subjects of CNSC, they promote the operationalization of each link of the innovation chain by playing the role of gluing and caulking.

4.5 Environmental Elements

From the perspective of system theory, CNSC can be regarded as the innovation subsystem within the national innovation system. It can be affected by the external innovation ecological environment on the one hand; and on the other hand, exert counterproductive influences on the external innovation ecological environment. Therefore, environmental factors are also important aspects that should be considered in investigating CNSC.

These environmental factors primarily include policy environment, economic environment, population environment, and cultural environment. Among these elements, policy environment includes national and local laws and regulations related to scientific and technological innovation, which guides and regulates the behavior

of innovation subjects. The economic environment primarily refers to the factor market perfection, product market activity, capital market supply and demand, and infrastructure construction, which affects the driving force of scientific and technological innovation. The population environment covers the total population, age structure, education structure and migration and change characteristics, which affects the supply and flow of innovative talents. The cultural environment includes the customs and other factors that influence the basic values, concepts, preferences and behaviors of a society, and produces innovation.

5. Structure and Relationship of CNSC

5.1 Comprehensive Model of CNSC

As a large-scale and complex innovation system, CNSC has the common characteristics of innovation system. Based on the previous analyses and existing research results, this study divides CNSC into three main innovation subject systems—that is, knowledge innovation system, technology innovation system, and innovation result diffusion system—and three innovation support systems—that is, management and operation system, resource support system, and environmental support system. Each subsystem is composed of some system elements according to specific structural relations, and the overall system of the CNSC is formed between subsystems according to specific structural relations. The structural model is shown in figure 2.

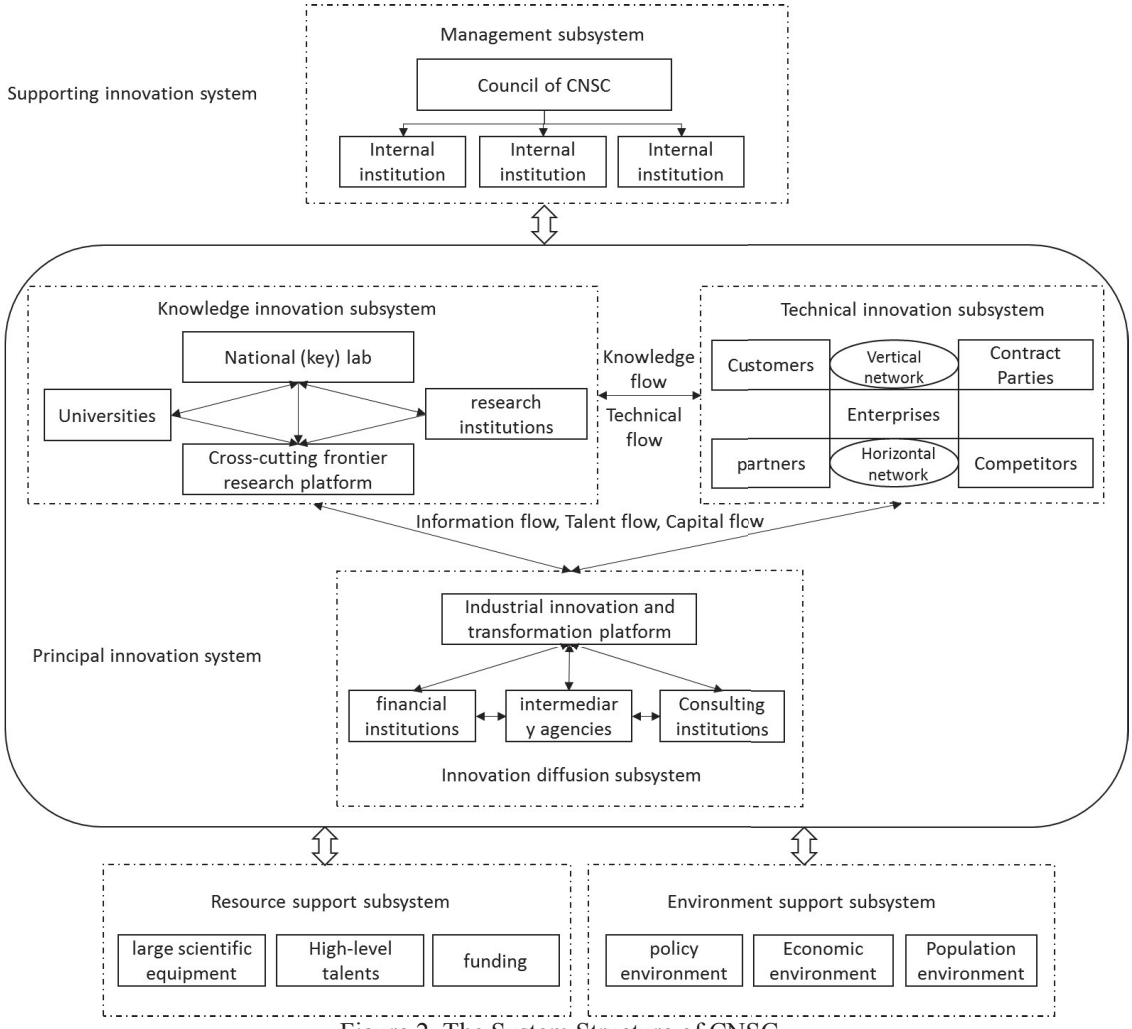

Figure 2. The System Structure of CNSC

5.2 Structural Relationship of CNSC

5.2.1 The Vertical hierarchical relationship.

Generally, CNSC has three levels which are highly correlated with each other. High-level system is composed of low-level system, while low-level system is composed of lower-level system. At the first level, CNSC is a high-level system which is composed of the innovation subject system and the innovation support system. An the second level, innovation main body is composed by the subsystems of knowledge innovation, technology innovation system and innovation diffusion subsystem. The innovation supporting system is separated into

management operations support subsystem, resources subsystem and environment subsystem, which all together exchanging knowledge, technology, information, talent, capital exchange and flow. At the third level, the subsystem of knowledge innovation primarily includes national laboratories, institutions of higher learning, research institutes and cutting-edge cross-innovation platforms. The main element of the subsystem of technological innovation is enterprise. The subsystem of innovation diffusion includes elements of industrial innovation achievement transformation platform, financial institution, intermediary institution and consultation institution. Moreover, at a higher level, the integrated national science center is also a subsystem of the national innovation system.

5.2.2 Horizontal Division of Labor.

Each subsystem of the integrated national science center has its own boundary and horizontal division of labor. At the first level, the innovation subject system is positioned to directly participate in the innovation activities, and the innovation support system provides guarantee support for the development of the innovation subject system activities. At the second level, knowledge innovation subsystem is mainly to carry out the chain of the basic research and applied basic research, technology innovation subsystem is focus on technology research and development, process improvement, product development, application research activities such as diffusion of innovation subsystem is the transfer of research achievements transformation and communication transmission, and three support system respectively responsible for provide operations management support for the innovative activities smoothly, equipment, capital and other resources to support and peripheral environment support. At the third level, each factor plays a different role (e.g., knowledge innovation subsystem), while each factor is mainly positioning is knowledge innovation. Nevertheless, national laboratory emphasizes on original innovation, universities and research institutes on taking the innovative talent training tasks, cutting-edge creative cross platform on the multidisciplinary, multidisciplinary innovation activities.

5.2.3 Relationship of Strategic Location.

The strategic contribution of the subsystems of the CNSC varies, leading to different primary and secondary relationships. At the first level, the innovation subject system is the direct creator of the innovation value and is in the strategic center position, while the innovation support system is the indirect creator of the innovation value, which is indispensable but in a relatively secondary position. At the second level, within the innovation main body system, as the source of value innovation, subsystem of knowledge innovation is at the core of strategy. Because it has a comprehensive strategic focus that is positioning at the national center for science in the processes of basic research and knowledge creation. Moreover, the knowledge creation situation determines the innovation value chain backend technology innovation and diffusion of innovation; therefore, knowledge innovation subsystem operating performance to a large extent reflects the comprehensive national center for science in the success or failure. At the third level, as the most advanced scientific research subject representing the original innovation level of the country, the national laboratory is at the center of the subsystem of knowledge innovation. Compared with the national innovation system, CNSC is at the strategic center position.

5.2.4 Loose Coupling Relationship.

CNSC includes the coupling relations among subsystems at all levels as well as the internal coupling relations among subsystems, which leads to the amplification or reduction of their original attributes. To be specific, on the one hand, the subsystem of CNSC is partial to the system at a higher level. Only when the subsystems cooperate and share resources with each other, their strengths and weaknesses can be fully complemented towards achieving the value effect. On the other hand, each subsystem has its relative independence and heterogeneity, as well as its own value orientation and interest appeal. This typical loosely coupled relationship requires CNSC during the operating process to solve the contradictions between independence and integrity unit, and between heterogeneity and interdependence. That is, the relative interdependence of each subsystem and the comprehensiveness of CNSC as a whole system should be both considered. Thus, each component on the creative value chain can generates the benefits of cooperation and division of labor, which is likely to enhance the overall efficiency of innovation.

6. Conclusion

In the current study, a systematic analysis of CNSC has been conducted to help researchers and practitioners comprehensively understand CNSC in China. It is found that CNSC is characterized by integration and complexity, competitiveness and cooperation, self-organizing and other-organizing. Targeting on this central task of science and technology innovation, CNSC contains a great amount of innovative elements, including platform factor, resource factor, subjective factor, service factor and environment factor and etc., which forms complex networks among innovation chain, talent chain, policy chain, industry chain, and transforming complex between chain. Furthermore, this study categorized CNSC into three innovation subject systems (i.e., knowledge innovation system, technology innovation system, and innovation result diffusion system), as well as three innovation support systems (i.e., management and operation system, resource support system, and environmental support system). Each subsystem is composed of some system elements according to specific structural relations.

Meanwhile, the entire system of CNSC is formed between subsystems according to their specific structural relations.

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