

Research on the Multi-agent Synergic Mechanism for the Opening and Sharing of Big Data in Chinese Agriculture*

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Abstract—Agricultural big data has become the basis and foundation of decision-making in agricultural development. Highly efficient and synergic open data play a significant role in the improvement of agricultural science and technology strength and data service level, and the coupling catalysis of industry integration. Through literature research, this paper reviews the theoretical research and practice of the multi-agent synergic mechanism for the opening and sharing of big data in Chinese agriculture. Based on the current application situation, this paper introduces the synergy theory to construct the synergic framework of data opening and sharing, with the four-dimensional synergic relationship of subjects, functions, motivations and goals, analyzes the composition and positioning of data generation, data utilization, data management and technical subjects, and discusses the realization path at last.

Keywords—*agricultural big data; multi-agent synergy; opening and sharing; mechanism*

I. INTRODUCTION

Agricultural big data is an advanced stage of the application of computer technology and IOT technology derived from the continuous development of intelligent, synergic, precise, networked, proactive and ubiquitous modern information technology, and an abstract description of structured, semi-structured and unstructured multi-dimensional, multi-granularity, multi-model and multi-form massive agricultural data. The application of agricultural big data not solves the problem of data storage and application. Problems needs solving also include the collection and utilization of real-time data, data crossing and recombination analysis of different industries and structures. In recent years, the academic community has conducted a lot of in-depth research on the openness and sharing of agricultural big data and realized that openness and sharing is the only way to realize the application of agricultural big data and an effective way to solve the problems of "information island" and "information silo" [2]. Since the state council of China

*Fund project: this paper is the phased achievement of agricultural big data application architecture research (2017zgng04) under the background of "Internet +", the open fund project of China agriculture-valley development research center.

issued the "Action Plan for Promoting the Development of Big Data" in August 2015, governments at all levels have in succession unveiled the "Big data industry development plan", "Agricultural and rural big data pilot program", "Implementation opinions on promoting the development of big data in agriculture and rural areas" and other documents. These documents clearly focus on opening up and sharing data, accelerating the building of a unified and open platform, and steadily promoting the effective opening of data resources. However, in terms of the overall progress, the development of China's agricultural big data opening is relatively slow, mainly represented in two aspects [3]: first, it ranks in the middle of the global open data index, and there is still a certain gap with developed countries in Europe and America; second, regional development is uneven in that some provinces and cities have made great progress, while others are still in the exploratory stage. This study, combined with the synergistic theory, sorts out the theoretical research and practice of the opening and sharing mechanism of big data in China's agriculture. Based on the existing research results and in combination with the status quo of China's agricultural big data opening, it constructs an open and shared framework with Chinese characteristics. Through the analysis of the four-dimensional synergistic relationship among synergic subjects, synergic functions, synergic driving forces and synergic objectives, it explores the implementation framework and mechanism of China's agricultural big data development strategy.

II. RESEARCH STATUS AND PROBLEMS OF SYNERGETIC APPLICATION OF AGRICULTURAL BIG DATA

A. Analysis of Synergetic Application Status of Agricultural Big Data

As the native data integrating regional, seasonal, diverse and periodic characteristics of agriculture, agricultural big data plays a positive role in promoting modern agriculture, grain security and food safety [4]. In recent years, with the continuous advancement of informatization in China, the basic environment of agricultural big data has been optimized, and a number of agricultural big data open platforms have been preliminarily formed. The data quality

and opening level have also been improved to a certain extent. However, it is still in the initial stage, and there are still obvious problems such as non-uniform standards, inconsistent specifications, lack of synergetic mechanism of construction units and "information island" [5].

At the level of policy coordination, some scholars have pointed out the necessity and feasibility of the research on agricultural big data policy synergy, and put forward relevant Suggestions. The United States, the United Kingdom, Canada and other countries, due to their early data opening policies and practical studies, have established a comprehensive and coordinated policy system under sound laws and regulations, and fully combined the needs of society and enterprises to provide all-round data services through various platforms and channels. For example, to increase transparency in government information, the American government introduced the "data.gov" in May 2009 and announced a plan for an "open government (Open Government Initiative)". The plan proposes an integrated and open network platform to publicize government information, work procedures and decision-making process, so as to improve the accessibility of government information and strengthen responsibilities and improve efficiency. The American agricultural big data system has the characteristics of taking the official data of the ministry of agriculture as the core and rich data content [6] [7]. In order to integrate public data of member states, the EU has built a normalized and standardized data sharing database for multiple member states to provide public data resources for economic development and industrial innovation. The key lies in the design of transnational and trans-regional opening policies and synergic framework, which coordinates the management and utilization needs of each opening subject and utilization subject, having a strong synergy and systematic characteristics [8] [9]. In addition to the basic characteristics of big data, agricultural big data is characterized by strong periodicity, regionalism and intersectionality. Effective data collection, data ownership division and data security are prominent problems in the process of data construction. The solution of these problems depends on the legal environment and effective policy system.

At the operational level, the methods, processes and platform designs of data opening and sharing have obvious effects on data collaboration, sharing and utilization. Agricultural big data mainly comes from the Internet of things, biological information data, resource and environment data and agricultural statistics. From the perspective of the field, with agriculture as the core, (covering sub-industries including planting, forestry, animal husbandry and aquaculture and product processing industry, etc.), the data gradually expand to the relevant upstream and downstream industry(including feed, chemical fertilizers, pesticides, agricultural machinery, warehouse storage, slaughtering and meat processing industry, etc.), and the macroeconomic background data, including statistics, import and export data, price data, production data, meteorology, disaster etc. need to be integrated [10]. From the perspective of region, not only the national level data, but also provincial and municipal data and even prefecture-level data should be

included, so as to provide a basis for regional agricultural development research. From the perspective of breadth, it not only includes statistical data, but also includes basic information of agriculture-related economic subjects, investment information, shareholder information, patent information, import and export information, media information, geospatial coordinate information, etc. From the perspective of professionalism, specialized data resources in the field of agriculture should be constructed step by step, and then subfield data resources of the specialty should be gradually and orderly planned [11]. The timeliness, multi-source and other characteristics of agricultural big data raise higher requirements and challenges for the acquisition and processing of data in the application of agricultural big data.

In conclusion, the synergy of agricultural big data should contain two meanings: On the first level, it means the synergy of data resources, including the business synergy between various subjects, the synergy between data indicators and targets, and the synergy of data constraints, such as the synergy between the production, processing and sales of agricultural products. All these require some tools and interfaces to coordinate and unify, so as to ensure the consistency of data. On the other level it refers to the synergy among subjects, including the diverse collaboration of multiple subjects based on common goal and internal motivation and end result is not simply the sum of individual contributions. Although the viewpoints of each subject are diverse, independent and equal, they can be effectively aggregated through effective coordination [12].

B. The Proposing of the Synergetic Mechanism of Agricultural Big Data Opening and Sharing

Based on existing research and practice, basic data collection and processing, policy synergy and the rights and responsibilities of subjects are the key to the application of agricultural big data. These factors can be effectively aggregated only in the framework scope of the overall linkage, so as to give play to the value and role of data. At present, China's agricultural big data application has been given full attention at both central and local levels, but problems such as data standards and data ownership reflect the lack of consideration for the synergic design of total factors such as policies, subjects and technologies in data application. In terms of theoretical research, systematic research on the application of agricultural big data has not been formed, which results in the lack of basis and guidance for the practical work of data application to a certain extent; on the practical level, the policy formulation needs to further combine the national development strategy and the actual situation of various regions to carry out targeted path planning and method selection, so as to form a cross-level and cross-regional open synergic system of agricultural big data application.

III. COMPATIBILITY BETWEEN SYNERGETICS AND AGRICULTURAL BIG DATA OPENING AND SHARING

Synergetic theory is an important branch of system science, which mainly studies how an open system away from the equilibrium state can spontaneously present the

ordered structure in time, space and function through its own internal synergetic effect under the condition of material or energy exchange with the outside world [13]. The self-organizing theory of synergetics aims to explain the process of system evolution from disorder to order. In this transition, the time structure or space structure is generated in the form of self-organization on the macro scale, which is essentially the process of self-organization within the system, and synergy is the form and means of self-organization [14].

A. The Agricultural Big Data Application Environment Is Characterized by Remarkable Openness

Synergetic theory holds that to realize self-organizing process, a system must have the conditions for self-organizing. First of all, the system must be open and able to communicate with the outside world in terms of material, energy and information, so as to ensure its survival and development; secondly, the system must have nonlinear coherence, and the internal subsystems must coordinate and cooperate to reduce internal consumption and give full play to their respective functional effects [15]. However, the application environment of agricultural big data itself has obvious openness and complexity. On the one hand, the agricultural big data application environment is complex and changeable, which needs not only to ensure the internal coordination of data, but also to play a role together with the external correlation system and big data platform, forming an open dynamic system. On the other hand, with the development of Internet of things, cloud computing and other network technologies, as well as the constant changes in agricultural production environment and production process, agricultural big data platform should respond to the changes in the environment in a timely manner, continuously integrate data resources, expand the information dimension, and ensure the orderly development of the application system.

B. The Subjects of Agricultural Big Data Generation and Application Features Order Parameters Prominently

Order parameter theory is the core concept in the three theories of synergetics. It holds that the order parameter is the most prominent symbol of the qualitative leap before and after the phase change of the system, which represents the ordered structure and type of the system and is the concentrated embodiment of the degree of the subsystem's involvement in the synergic movement [16]. According to synergetics theory, it is generally believed that order parameters have the following four characteristics [17]. First, the order parameter is the macroscopic parameter of the system, which can describe the overall behavior of the system, in line with the non-superposition principle proposed by the general system theory, and is formed by the nonlinear action of each state variable in the system. Second, the order parameter is the representation and measurement of the system synergy effect, which is not imposed on the system from the outside, but from the inside. Third, order parameters govern other variables in the system and dominate the evolution of the system. Fourth, the order parameters have relative stability. Agricultural big data application involves agricultural departments, research institutes, agricultural

enterprises, rural areas and farmers, and other subjects relying on the configuration of land, capital, information, human and other resources. These resources are not externally imposed on the system, and their evolution speed is fast and relatively stable, which jointly promote the system to realize the self-organization form from disorder to order.

C. The Realization of Agricultural Big Data Value Is Characterized by Strong Synergy and Imbalance

Synergetic theory represents a kind of benign evolution process for realizing the overall goal of the system, which relies on the synergetic nonlinear interaction among subsystems to realize the phase change of the system structure and morphology. The correlation between subsystems is more dominant than the independent movement of subsystems and thus becomes the leading role [18]. The division of agricultural big data by processing process involves data collection, storage, analysis, application and other subsystems, and mainly focuses on agricultural environment and resources, agricultural production, agricultural market and agricultural management and other subsystems by industrial chain. The internal running state of each subsystem directly affects the output effect of the whole system. At the same time, there are competitive relations and cooperative relations among the subsystems. In order to achieve a specific value output, it is necessary to coordinate the various systems from a global perspective, so that the macroscopic organic whole structure and the microscopic subsystems are interrelated. The evolution direction and process of the whole system are dominated by competition and cooperation, laying a structural foundation for the continuous value output of agricultural big data.

Synergetic theory has the characteristics of universality, and the agricultural big data application system for the purpose of improving openness and sharing is itself a complex open system. Therefore, synergetic theory is introduced into the study of agricultural big data application countermeasures to provide a new thinking perspective and practical exploration for the cognitive and optimization of synergetic development among multiple subjects of agricultural big data.

IV. SUBJECTS COMPOSITION AND SYNERGISTIC FRAMEWORK OF AGRICULTURAL BIG DATA APPLICATION

Multi-agent synergy is the process, mode of action and procedure in which various subjects interact (conflict and cooperation) and make joint efforts to achieve the set goals or agreed goals. Therefore, the construction of synergistic framework focuses on the composition of each subject in the system and their interaction relations, so as to maximize the role of each heterogeneous subject. Based on the synergistic view, this paper constructs a synergistic framework of agricultural big data opening and sharing centering on data generation, data utilization, data management and technology. Driven by multiple value demands such as data service, economic development and public demand, this goal is realized around values such as data value and public interest. Various subjects cooperate with each other to form

an organic organizational system with linkage effect (as shown in "Fig. 1").

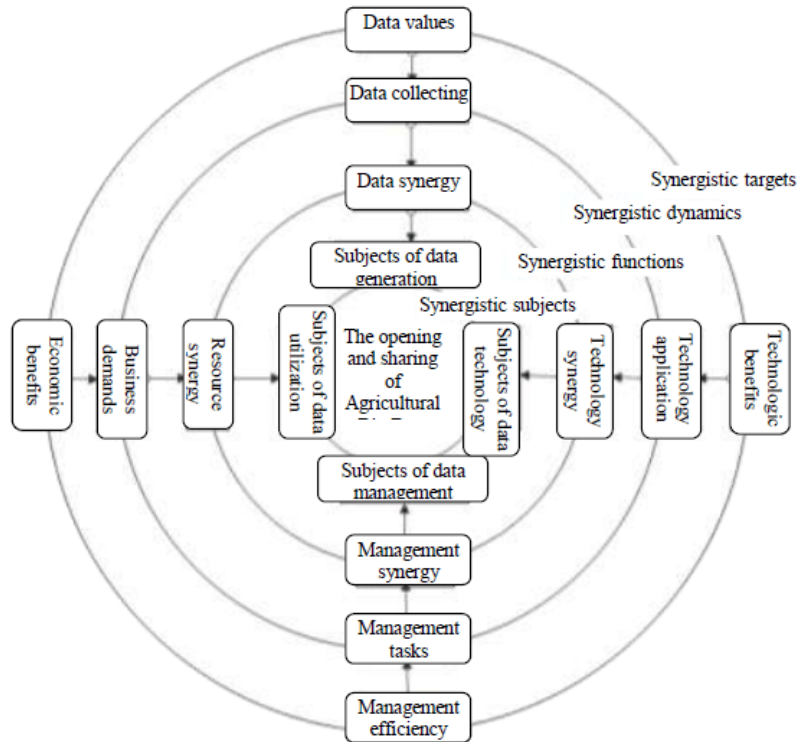


Fig. 1. Multi-agent synergistic framework of China's agricultural big data opening and sharing.

A. Subjects Composition and Positioning

1) *Subjects of data generation*: The subjects of data generation include agricultural departments, statistical departments, environmental monitoring departments, scientific research institutes, public institutions and organizations and individuals involved in agriculture. They are the owners of raw materials in the synergistic framework and the source of agricultural big data applications. Compared with the traditional agricultural information disclosure, the data generation subjects are no longer limited to the government and scientific research institutions. They can also include non-profit organizations, industrial companies, enterprises, social networks and other social organizations that complete data generation and data preprocessing under certain laws and agreements, which can fully ensure the consistency and effectiveness of data.

2) *Subjects of data utilization*: Data utilization subjects can also be called business subjects, including organizations and individuals with information and business requirements related to agricultural big data. In the Internet environment, the subjects of data utilization show an obvious trend of diversified development. They have different value demands for agricultural big data in different dimensions, and higher and higher requirements for the quality of data at the same time. At present, in the process of data utilization, there are problems such as low utilization rate of data, weak ability of data analysis and interpretation. At the policy level, there is no relevant data protection construction in terms of the data

utilization mode, approach, target and security of the data utilization subjects.

3) *The subjects of data management*: The basic task of the data management subjects is to manage the agricultural big data in a systematic and scientific way, and integrate the multi-source and heterogeneous data among the producing subjects. On the one hand, it is to integrate and plan the original single component and single service subsystem into an organic whole, and provides complete data services. On the other hand, it is to guarantee the data file transmission and the authenticity and security of the use process by various means such as personnel, technology and system.

4) *The subjects of data technology*: Data technology is the key element to guarantee the application of big data, and its subjects include organizations and institutions that provide data collection, preprocessing, storage, analysis and mining methods and technologies. The openness and sharing of agricultural big data requires that the methods and technologies of each link of data processing have a high degree of unity, comprehensiveness and efficiency. The degree of refinement, integrity and using orientation of data affect users' cognition and understanding of data, thus affecting the using effect of data. According to the needs and utilization preferences of different data subjects, efficient and reliable data technology services can be used to integrate diverse data resources from heterogeneous data sources and different channels to establish unified, complete, accurate and real-time data services.

B. Synergistic Relationships Among Multiple Subjects

Cooperation among subjects is an important means to solve the problems of agricultural big data opening and sharing. A four-dimensional network of cooperative subjects, functions, motivations and goals is formed around the concept of agricultural big data opening and sharing (as shown in "Fig. 1"). Due to the limited title of this paper, the internal coordination and policy coordination are not discussed.

V. THE IMPLEMENTATION PATH OF THE SYNERGETIC MECHANISM OF BIG DATA OPENING AND SHARING IN CHINA'S AGRICULTURE

A. Multi-agent Synergetic Relationships Should be Optimized on the Premise of Target Synergy

Target synergy is the premise of open and shared agricultural big data. Different subjects, such as the government, agriculture-relevant departments, agriculture-related enterprises and technical service companies, have different functional positioning, resource capabilities and interest demands in the application of agricultural big data, which leads to different or even contradictory value demands and behaviors, thus have negative effect on the opening and sharing of the synergy. Therefore, on the basis of clarifying the overall goal, level goal, regional and industrial application goal of agricultural big data application, the top-level design and overall planning should be strengthened. In the application process, the idea of multi-agent cooperation and win-win and the overall idea of "multiple small targets constitute a big target" should be integrated to strengthen the structural adjustment and organizational integration among data generation subjects, management subjects, technical subjects, and utilization subjects, and to strengthen the interactive mechanism among various subjects. At the same time, it can also meet the benefit demand of each subject, and finally achieve the goal of multi-party win-win cooperation.

B. The Main Effectiveness Should be Given Play to Based on Functional Synergy

Functional synergy is the foundation of agricultural big data opening and sharing. To promote the realization of data application goals, it is necessary to focus on the synergetic functions of each subject. Due to the technical limitations and lack of talents, as well as the contradiction between the explicit cost of the subjects and the implicit benefit, a prominent problem has been caused that the functional synergy cannot meet the public demand. The key functions of each subject should be highlighted based on their functional characteristics. The combination of internal source and external force is adopted to promote the function and management innovation of synergetic subjects through systematic and structured platform construction, so as to give full play to the efficiency of synergetic subjects.

C. The Quality of Open and Shared Synergy Should Be Improved with Dynamic Synergy as the Guarantee

Dynamic synergy is the guarantee for agricultural big data to realize high-quality data service. On the premise of establishing the overall goal, the incentive mechanism, system and interest coordination mechanism should be established to increase the motivation to participate in synergetic management and improve the quality and efficiency of data opening and sharing. First of all, coordination and division of responsibilities among different subjects should be strengthened to build a mechanism of power and responsibility distribution centering on the openness and sharing of agricultural big data. Construction elements should be allocated under the guidance of objectives to strengthen the overall action ability of synergetic subjects. At the same time, it is necessary to strengthen the coordination mechanism of the interests of synergetic subjects, grasp their interest demands and synergetic power, create common interests by balancing the interests of the subjects, and promote the establishment of sustainable synergetic relations.

VI. CONCLUSION

The synergetic framework of agricultural big data openness and sharing includes five main parts: data generation, data utilization, data management and data technology. All subjects have the same status and coordinate with each other to realize data opening and sharing, forming a four-dimensional synergetic relationship of subject synergy, functional synergy, dynamic synergy and target synergy. In order to meet the needs of different levels of users for the sharing of agricultural big data and realize the service-oriented and user-oriented open data sharing service, it is urgent to improve the benefit synergy mechanism, take the dynamic synergy as the guarantee, strengthen the synergetic relationship between different subjects, give full play to the subjects efficiency, and improve the quality and efficiency of data opening and sharing synergy.

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