Profit Growth and Innovation: Application of Big Data Analysis Technology in Agricultural Economic Management

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Abstract In this paper, the application of agricultural big data in agricultural economic management is deeply explored, and its potential in promoting profit growth and innovation is analyzed. However, challenges persist in data collection and integration, limitations of analytical technologies, talent development, team building, and policy support when applying agricultural big data. Effective application strategies are proposed, including data-driven precision agriculture practices, construction of data integration and management platforms, data security and privacy protection strategies, as well as long-term planning and development strategies for agricultural big data, to maximize its impact on agricultural economic management. Future advancements require collaborative efforts in technological innovation, talent cultivation, and policy support, to realize the extensive application of agricultural big data in agricultural economic management and ensure sustainable industrial development.

Key words Agricultural big data, Precision agriculture, Data-driven, Data security and privacy

0 Introduction

With the increase of global population and the intensification of resource and environment constraints, agricultural economic management is facing multiple challenges such as improving production efficiency, optimizing resource allocation, and sustainable development. The traditional agricultural management model is difficult to adapt to the complex and changing needs of modern agricultural development due to issues such as information asymmetry and decision-making lag[1-2]. In this context, the rapid development of information technology has injected new momentum into agricultural transformation. As a new generation of production factors, agricultural big data is becoming the core engine for promoting agricultural modernization and industrial upgrading. Agricultural big data integrates heterogeneous data from multiple sources such as climate, soil, production, and market, and provides scientific basis for accurate decision-making throughout the entire agricultural production process. It has shown significant value in optimizing industrial structure, reducing resource consumption, and enhancing supply chain resilience. Currently, the application of agricultural big data in agricultural economic management has achieved phased results. Research has shown that data-driven precision agriculture practices can achieve precise water and fertilizer application and intelligent pest and disease warning, increasing production efficiency by 20% -30%[3]. In supply chain management, big data analysis technology helps predict market demand and optimize logistics, significantly reducing the loss rate of agricultural products. However, the fragmented nature of agricultural data, technological barriers to transformation, and lack of institutional safeguards pose multiple obstacles to the release of data value. Specifically, the lack of cross departmental data sharing mechanisms hinders the efficiency of resource integration, weak digital capabilities of small and medium-sized farmers form a "data gap", insufficient adaptability of algorithm models to agricultural scenarios affects decision-making accuracy, and the absence of data security and privacy protection mechanisms threatens the sustainability of applications. These contradictions highlight the systemic obstacles to the transformation of agricultural big data applications from theoretical potential to practical effectiveness[4].

Based on the practical needs of agricultural economic management and the trend of digital transformation, this paper systematically explores the application mechanism, practical path, and limiting factors of agricultural big data. By deconstructing the value chain of "data collection-integration analysis-decision support", its mechanisms in enhancing decision-making scientificity, driving industrial upgrading, and enhancing sustainability are revealed. Meanwhile, multidimensional solutions are proposed to address key bottlenecks such as data governance, technology adaptation, and institutional safeguards. The research results provide not only a theoretical framework for the digital transformation of agricultural economic management, but also practical references for the government to formulate agricultural data policies and enterprises to optimize data application models.

1 Overview of agricultural big data

1.1 Definition and development of agricultural big data Agricultural economic management is the collective term for a series of tasks that utilize agricultural technology foundations and agricultural economic statistics to plan, organize, control, and coordinate economic activities such as production, exchange, distribution, and consumption in the overall agricultural production process,

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and motivate personnel to achieve expected goals. With the rapid development of information technology, agricultural big data, as an emerging information processing method, has been widely applied in agricultural economic management. It has shown great potential in improving agricultural production efficiency, promoting industrial upgrading, and enhancing agricultural sustainability[5]. Agricultural big data refers to the use of big data analysis techniques to process and analyze massive amounts of data related to agriculture, in order to obtain valuable information and knowledge, and provide decision support for agricultural production, operation, and management.

The deep application of big data technology in the field of agriculture has increasingly highlighted its role in agricultural economic management. Through big data analysis, precision agriculture management can be achieved, improving the scientificity and accuracy of decision-making, optimizing industrial structure, and enhancing agricultural production efficiency and sustainability. For example, using big data can accurately monitor and predict crop growth environment, pest and disease laws, and market demand, optimize production plans, reduce resource waste, and improve product quality and output efficiency[6]. However, the applications of agricultural big data also face challenges such as difficulty in data collection and integration, analysis technology bottlenecks, shortage of professional talents, and insufficient policy and regulation support. Data security and privacy protection issues cannot be ignored.

To leverage the role of agricultural big data, effective strategies need to be developed, including implementing data-driven precision agriculture practices, building a data integration management platform, implementing data security and privacy protection strategies, and formulating long-term development strategies[7]. Through these strategies, it could fully tap into the potential of agricultural big data in promoting innovation in agricultural economic management and enhancing industrial competitiveness. The rapid development of agricultural big data has brought new tools and methods for agricultural economic management, but it is also accompanied by new challenges that require coordinated promotion in technological innovation, talent cultivation, policy support, and other aspects, to achieve its widespread application and sustainable industrial development.

1.2 Value and application prospects of agricultural big data As an emerging resource, agricultural big data is rapidly developing globally and has enormous potential for application in agricultural economic management[8]. Firstly, by integrating multi-link agricultural data, it provides comprehensive information for decision-makers, helping to accurately match market demand, optimize resource allocation, and improve production efficiency and product quality. Secondly, it promotes the transformation of the agricultural industry towards technology intensive and information-based development. Through data analysis, it identifies production problems and opportunities for improvement, and promotes technology and management innovation[9]. In addition, it helps to achieve precision agriculture, finely manage the entire production process, ensure food safety and quality, reduce resource consumption, and achieve sustainable development.

However, the application of agricultural big data also faces technical issues such as data collection, integration, and analysis, as well as socio-economic problems such as talent cultivation and policy and regulation support[10]. The solutions to these problems require joint efforts from the governments, enterprises, and academia through measures such as improving policies, providing technical support, and strengthening talent cultivation. In short, as an important tool for agricultural economic management, agricultural big data has enormous potential, but it needs to be continuously explored and improved in application strategies to fully leverage its important role in enhancing agricultural competitiveness, promoting industrial upgrading, and advancing sustainable development.

2 Role of agricultural big data in agricultural economic management

2.1 Improving the scientificity and accuracy of decision-making Agricultural big data integrates multi-source data such as climate change, soil conditions, crop growth patterns, and market demand to provide accurate information support for agricultural production decisions, significantly improving the scientificity and accuracy of decision-making. In modern agricultural economic management, the application of big data technology can help decision-makers gain a deeper understanding of various aspects of agricultural production, predict market trends, optimize resource allocation, improve product quality, and monitor the efficiency of the entire supply chain. Besides, big data tools could be used to analyze consumers' behavior and market demand, which can help agricultural product production and sales enterprises more accurately position the market, formulate effective market strategies, and thus improve the market competitiveness of their products[11].

In addition, agricultural big data can also help achieve sustainable development goals. By monitoring and analyzing the energy and water consumption in the agricultural production process, it could optimize resource allocation, reduce waste, and promote sustainable resource utilization. In addition, by combining advanced technologies such as artificial intelligence, it aims to enhance the automation and intelligence level of agricultural production, reduce labor costs, and improve production efficiency and product quality. But to fully leverage the role of agricultural big data in agricultural economic management, it is necessary to overcome challenges such as data collection and integration, analysis technology, and talent cultivation, and promote technological innovation with policy and regulation support[12].

2.2 Promoting the optimization and upgrading of industrial structure Agricultural big data collects, integrates, and analyzes massive amounts of data from all aspects of agriculture through information technology, providing scientific basis for decision-making. In practical applications, it should promote the transformation of the agricultural industry towards efficiency and intelligence. For example, through detailed data analysis of planting and breeding industries, precise fertilization, irrigation, and pest control can be achieved, which not only improves the efficiency of agricultural production but also helps reduce environmental pollution

and resource waste. In addition, the application of big data technology can also promote the optimization of agricultural product supply chains, improve product quality and service levels, and enhance the market competitiveness of agricultural enterprises.

However, the application of agricultural big data faces challenges in data collection and integration, including accuracy, completeness, and technical requirements for data collection and processing. In addition, the technical challenges of data analysis and knowledge discovery, such as the complexity of data mining and model building, are also urgent issues that need to be addressed. Moreover, the cultivation of agricultural big data professionals and the support of policies and regulations also need to be promoted synchronously, to ensure the effectiveness and security of agricultural big data applications.

2.3 Enhancing the efficiency and sustainability of agricultural production In the current context of globalization and informatization, the rise of agricultural big data provides innovative solutions for traditional agricultural economic management. By collecting and analyzing a large amount of agricultural related data, new perspectives and tools have been provided to improve the scientificity of decision-making, promote the optimization and upgrading of industrial structure, and enhance the efficiency and sustainability of agricultural production.

Firstly, agricultural big data helps producers make more scientific and accurate decisions by providing multidimensional information such as precise market information, climate prediction, and crop growth monitoring. For example, by analyzing historical climate data and current meteorological information, the timing of sowing and harvesting can be optimized to maximize yield and quality. Secondly, information sharing and resource allocation optimization can be achieved at various stages of the industrial chain by utilizing agricultural big data. This can not only improve the operational efficiency of the entire industry chain, but also help achieve precision agriculture, reduce unnecessary resource waste, and enhance the sustainability of agricultural production. In addition, the application of agricultural big data can also promote the application and promotion of new agricultural technologies. For example, the use of intelligent devices could improve the automation and intelligence level of agricultural production. This can not only rise labor productivity, but also improve working conditions and reduce production costs. However, the application of agricultural big data in agricultural economic management also faces many challenges, including technical difficulties in data collection and integration, limitations in data analysis technology, lack of professional talents, and incomplete policies and regulations. Therefore, future research needs to make breakthroughs in technological innovation, talent cultivation, policy support, and other areas, to fully tap into the potential of agricultural big data in improving agricultural production efficiency and sustainability.

3 Challenges and opportunities of applying agricultural big data to agricultural economic management

3.1 Difficulties in data collection and integration As an emerging information resource, the application of agricultural big data in agricultural economic management is gradually becoming a key force in promoting agricultural development. With the rapid development of information technology, the amount of data generated in the agricultural production process is exploding, including multidimensional information such as climate change, crop growth, and market demand. The effective collection and integration of these data is a prerequisite for unleashing the value of agricultural big data. However, the application of agricultural big data in agricultural economic management currently faces many challenges.

Firstly, data collection is difficult due to the natural conditions of agricultural production and the imperfect data collection equipment, which limits the completeness and accuracy of the data. Secondly, the difficulty of data integration is high. There are various types of agricultural data, including structured data, unstructured data, and time series data, which require professional data processing techniques and platforms for integration and analysis. In addition, data standards vary among different regions and institutions, and there is a lack of unified sharing mechanisms, which limits the utilization of data resources. To overcome the above challenges, a series of strategies need to be adopted. This includes establishing sound data collection and standardization processes, improving the quality and popularity of data collection equipment; developing and applying advanced data integration and analysis tools to improve the efficiency and accuracy of data processing; strengthening interdisciplinary talent cultivation and building a composite team composed of data scientists, agricultural experts, and management experts; finally, formulating corresponding policies and regulations, and establishing a legal framework for data security and privacy protection, to providing legal protection for the opening and sharing of data.

3.2 Technical challenges in data analysis and knowledge discovery With the rapid development of information technology, agricultural big data has become an important driving force for the development of modern agriculture. The application of big data technology in agricultural economic management can not only improve the scientific and accurate decision-making, but also promote the optimization and upgrading of industrial structure, and enhance the efficiency and sustainability of agricultural production. However, there are still many challenges in practical applications: firstly, difficulties in data collection and integration. Agricultural production involves a wide range of data types, including climate change, soil conditions, crop growth status, market demand, *etc.*, which need to be systematically collected and integrated. However, due to the decentralization of agricultural production and limitations in data collection technology, the integrity and accuracy of data are often difficult to guarantee. In addition, there are technical challenges in processing and analyzing different datasets. Secondly, there is a need for breakthroughs in data analysis and knowledge discovery technologies. At present, although there are many advanced big data analysis tools and algorithms, it is still challenging to effectively apply these tools and algorithms to the agricultural field and extract valuable information. The analysis of agricultural big data not only requires processing massive

amounts of data, but also needs to consider the spatiotemporal characteristics, dynamic changes, and other complexities of the data, which puts forward higher requirements for data analysis techniques. In addition, talent cultivation and team building are also important challenges currently faced.

3.3 Challenges of talent cultivation and team building Agricultural big data is a new engine driving agricultural development. With the continuous advancement of technology and explosive growth in data volume, how to efficiently utilize this data to guide agricultural production, optimize resource allocation, and improve economic efficiency has become a hot research topic. In this process, talent cultivation and team building are particularly important[13]. Firstly, the application of agricultural big data requires a large number of technical talents with professional knowledge and skills. These talents need to not only master the basic abilities of data processing and analysis, but also have a deep understanding of the agricultural field and be able to accurately understand the application value of data in agricultural decision-making. The current shortage of such talents limits not only the depth and breadth of the application of big data technology in the agricultural field, but also the intelligence of agricultural production and data-driven decision optimization. Secondly, in terms of team building, the application of agricultural big data requires interdisciplinary collaboration. This not only requires good communication and collaboration skills among project team members, but also requires them to jointly face a series of technical challenges such as data collection, processing, and analysis. In addition, team building also requires effective organization management and project management mechanisms, to ensure the smooth implementation of projects and the effective transformation of results. To this end, an ecological environment conducive to the growth of agricultural big data talents should be constructed from the dimensions of education and training, continuing education, and career development, such as improving relevant curriculum settings, strengthening practical teaching, providing interdisciplinary cooperation platforms, and establishing a mechanism for talent cultivation to meet the needs of enterprises.

3.4 Support and limitations of policies and regulations In the era of informatization, agricultural big data brings new tools for agricultural economic management, but its development is constrained by policy and regulatory factors. Firstly, policy support provides direction and guarantee for the application of agricultural big data. A series of policies introduced by national and local governments aim to promote the integration and sharing of data resources, creating a favorable external environment for the development of agricultural big data. For example, the government is promoting the establishment of agricultural big data platforms and encouraging data sharing, which can help improve the availability of data and the effectiveness of analysis. In addition, policies may also include financial support for the application of agricultural big data, such as providing funding assistance for related projects, to incentivize in-depth research and practice. However, regulatory restrictions are also an important challenge for the development of agricultural big data. Clear laws and regulations are needed to regulate and protect issues such as data privacy protection, intellectual property protection, and data security. The existing laws and regulations may not be sufficient to support the rapid development of big data technology, and need to be constantly updated and improved to adapt to the application of new technologies and the emergence of new models. Therefore, in order to promote the application of agricultural big data in agricultural economic management, it is necessary to continuously optimize policies and regulations. By improving data protection laws, formulating data sharing policies, optimizing financial support measures, *etc.*, a favorable external environment can be created for the development of agricultural big data, promoting innovation and upgrading of agricultural economic management.

4 Application strategies for agricultural big data

4.1 Practice of data-driven precision agriculture In the current information age, agricultural big data has become a key factor in promoting innovation in agricultural economic management and enhancing agricultural production profits. The application of agricultural big data can not only improve the scientificity and accuracy of agricultural economic management, but also promote the optimization and upgrading of industrial structure and enhance the efficiency and sustainability of agricultural production. Agricultural big data can provide decision-makers with more accurate information and predictions, thereby supporting more scientific decision-making. In addition, agricultural big data can also promote the application of new agricultural technologies and the development of new products, such as the practice of precision agriculture. Precision agriculture can achieve precise application of fertilizers, water resources, and pesticides through in-depth analysis of soil, climate, crop growth, and other data. This not only improves agricultural production efficiency, but also contributes to environmental protection and sustainable development. However, the complexity of data collection and integration, limitations of analytical techniques, shortage of professional talents, and support and limitations of policies and regulations coexist. Therefore, it is the key to unleashing the potential of agricultural big data and promoting the sustainable development of precision agriculture by building an efficient management platform for agricultural big data, formulating scientific data application strategies, and strengthening the construction of data security and privacy protection systems.

4.2 Construction of data integration and management platform With the rapid development of agricultural informatization, agricultural big data has become an important tool for promoting innovation in agricultural economic management, and building an effective data integration and management platform is the core of achieving precision agriculture and improving management efficiency. The core of the data integration and management platform lies in integrating dispersed data resources, creating an environment that integrates storage, management, and analysis, while meeting the needs of massive storage, powerful processing capabilities, and efficient analysis tools to explore data value, support decision-making, and business optimization.

When building a platform, the first thing to consider is data collection and integration. This includes collecting data from various sources such as farm management systems, remote sensing satellite data, climate monitoring stations, *etc.*, and standardizing and normalizing these data for subsequent processing and analysis[14]. In addition, the platform also needs an efficient data exchange and sharing mechanism to ensure real-time updates and secure transmission of data. Secondly, data security and privacy protection are also important aspects that must be considered when building a data integration and management platform. This not only involves the storage security of data, but also includes the security of data during use, such as preventing unauthorized access, data leakage, *etc.* Finally, the scalability and flexibility of the platform are also key considerations in design. With the continuous growth of data volume and changes in business requirements, the platform needs to be able to flexibly expand to meet future development needs.

In summary, an ideal data integration and management platform should be able to achieve efficient integration, secure management, intelligent analysis, and flexible expansion of data, in order to support the in-depth application of agricultural big data in agricultural economic management, and provide strong support for achieving precise management of agricultural production and scientific business decision-making.

4.3 Application of agricultural big data in supply chain management In the field of supply chain management, the introduction of big data technology provides new ideas and tools for optimizing supply chain management[15]. By implementing precise data analysis, information sharing and integration can be achieved at various stages of the supply chain, thereby improving the transparency and response speed of the supply chain. In supply chain management, agricultural big data can be used to predict market demand, optimize inventory management, improve logistics efficiency, and enhance the transparency of supply chain. For example, by analyzing historical sales data, climate change data, and agricultural production data, companies can more accurately predict market trends, arrange production plans reasonably, reduce inventory backlog and logistics costs[16]. In addition, utilizing big data analysis technology, enterprises can effectively control the risks of supply chain and respond to possible market fluctuations in advance. However, the application of agricultural big data in supply chain management also faces some challenges, such as difficulty in data collection, data integration and analysis techniques, lack of professional talents, and issues of data security and privacy protection. Therefore, it requires not only technological innovation, but also policy support and active participation of enterprises to build an effective application framework of agricultural big data.

4.4 Strategies for data security and privacy protection With the rapid development and application of agricultural big data technology, the generation, storage, processing, and transmission of large amounts of agricultural data have brought potential security risks. These risks include illegal access, tampering, and leakage of data, as well as privacy protection issues related to the reasonable and lawful use of data. Firstly, data security refers to the ability of data to effectively prevent unauthorized access and malicious attacks during storage, processing, and transmission, ensuring the confidentiality of data is not compromised. For example, using encryption technology, access control, network security protection and other means, it can effectively protect data from unauthorized third-party access[17]. Secondly, privacy protection refers to ensuring that personal privacy is not leaked or abused during the collection, analysis, and application of data. This requires the development of strict privacy protection policies and operational norms, as well as adherence to the principle of minimum necessity in data processing, limiting the acquisition and use of personal privacy information. In addition, it is necessary to strengthen the training and education of relevant personnel, to enhance their awareness of data security and professional ability in privacy protection.

5 Conclusions and prospects

This paper systematically explores the application value, practical path, and challenges of agricultural big data in agricultural economic management. Research has shown that agricultural big data significantly enhances the scientificity and accuracy of agricultural decision-making, optimizes industrial structure, and demonstrates enormous potential in improving production efficiency and sustainability by integrating multidimensional data resources. Specifically, agricultural big data has achieved precise control over the entire process through precision agriculture practices, supply chain optimization, and dynamic resource allocation, reducing resource waste and market risks, and providing new impetus for the high-quality development of the agricultural economy. However, the application of agricultural big data still faces challenges such as data fragmentation, technological complexity, talent shortage, and policy lag. To this end, the following strategies are proposed: firstly, building a unified data integration and management platform to achieve data sharing and standardized processing across departments and links; secondly, strengthening data security and privacy protection mechanisms, and establishing a technical framework that balances openness and security; the third is to promote collaborative innovation among government, industry, university, and research institution, and improve the talent training system and policy support network.

Future research can focus on three directions: first, exploring the integration path of emerging technologies such as artificial intelligence and blockchain with agricultural big data. For example, a trustworthy agricultural product traceability system could be built using blockchain technology. Second, it should strengthen the dynamic modeling capability of agricultural big data and develop lightweight analysis tools that meet the needs of small farmers. The third is to deepen the interdisciplinary research between agricultural big data and ecological economy, circular agriculture, and promote the transformation of agricultural economic management towards intelligence and green direction. Through continuous theoretical innovation and practical optimization, agricultural big data is expected to become the core engine driving agricultural modernization and rural revitalization.

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ment. The knowledge such as the regulations and rules, the operation of computer can be mastered systematically and comprehensively through lectures, training sessions and meetings. It is not difficult for the employees in vocational colleges, who are generally good at learning and mastering knowledge. It is the willingness and activeness that difficult to cultivate. Willingness and activeness can be stimulated by the performance evaluation. In vocational colleges with hierarchical asset management, asset management work covers a wide range of areas, including college asset managers, school (department) asset managers, and asset users (custodians), each with distinct job responsibilities. The vocational colleges should promote the performance evaluation system for asset management under the premise of giving full importance to asset management, clarifying the goals and responsibilities of each department and individual, evaluating the performance of departments and individuals based on the quantifiable tasks. Departments and individuals with high evaluation grades should be commended or rewarded, while those with low evaluation grades should face penalties and be required to rectify their issues.

3 Conclusions

During the period of rapid growth of state-owned assets of vocational colleges in China, it is essential to promote the management of the assets through equipment inventory, which can comprehensively reflect problems in daily asset management work. Taking these measures, such as accelerating the disposal of state-owned assets left over because of historical reasons and clarifying basic data on state-owned assets, establishing an internal unified management department and improving the assets management regulations of vocational colleges and applying the information technologies, the management work of state-owned assets will be improved, which will lay a solid foundation for the development of vocational colleges.

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