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Research on the Construction Path and Operational Mechanism of Rural Land Circulation Platform Based on Practical Exploration of Policy Support, Technology Empowerment, and Multi-Party Collaboration

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Abstract: The construction of the rural land circulation platform is a crucial aspect of deepening rural reform and promoting rural revitalization. This paper systematically explores the construction path and operational mechanism of the land circulation platform using a framework that analyzes policy support, technological empowerment, and multi-stakeholder collaboration, combined with typical cases and practical experiences. The research findings are as follows: Firstly, policy support serves as the institutional guarantee for platform construction. The central and local governments provide a legal basis and normative guidance for the platform's operation through policies such as improving the "separation of three rights" system for land, standardizing the circulation process, and publishing guiding prices for circulation. Secondly, technological empowerment is the core driving force for efficient platform operation. Technologies such as blockchain, big data, and cloud computing have facilitated the digitization and transparency of land circulation. Thirdly, multi-stakeholder collaboration is a critical mechanism for the platform's sustainable development. Governments, financial institutions, village collectives, and market entities form a network of shared interests. Practical experience has demonstrated that the land circulation platform effectively revitalizes rural resources, enhances agricultural efficiency, and promotes income growth for farmers through the organic integration of policies, technologies, and collaborative mechanisms. In the future, it is necessary to further strengthen data interconnectivity, improve risk prevention and control systems, and explore innovative models such as management right mortgages to inject sustained momentum into rural revitalization.

Keywords: Rural land circulation platform; Technological empowerment; Multi-stakeholder collaboration; Rural revitalization

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1. Introduction

1.1. Research background

1.1.1. The demand for a rural revitalization strategy and land circulation system reform

Rural revitalization is a powerful national strategy proposed by the General Secretary at the 19th National Congress of the Communist Party of China. To implement the rural revitalization strategy, we must adhere to the dominant position of farmers, adhere to the integration of urban and rural areas, and adhere to adapting measures to local conditions and proceeding step by step. Consolidate and improve the basic rural management system, ensure national food security, and firmly hold the bowls of Chinese people in their own hands [1]. The rural revitalization strategy is also the core path to solve the "three rural" issues and realize agricultural and rural modernization in the new era. With the intensification of the imbalance between urban and rural development, the inefficient utilization of rural land resources has become a key bottleneck restricting rural revitalization. Under the traditional small-scale peasant economy model, problems such as land fragmentation, abandonment and idleness, and irregular circulation are widespread, leading to obstacles to large-scale agricultural operations and weak growth in farmers' property income. In this context, deepening the reform of the land circulation system has become an inevitable choice to activate the potential of rural elements and promote agricultural modernization.

The central government has continuously released reform signals, clearly requiring the promotion of market-based circulation of land management rights based on the "separation of three rights." The 2025 Central Document No. 1 emphasizes that land circulation should follow the principles of "lawfulness, voluntariness, and compensation," prohibit administrative intervention, and encourage the stabilization of circulation fees through price index regulation to balance farmers' rights and interests with agricultural competitiveness. However, the traditional circulation model still faces multiple difficulties, such as information asymmetry, chaotic management of ownership, and insufficient financial support [2]. Therefore, building a standardized land circulation platform is not only an institutional guarantee for implementing national policies, but also a practical need to solve the difficulties of traditional circulation.

1.1.2. Practical value of digital platforms in solving the difficulties of traditional circulation

Digital economy empowerment of land circulation is one of the strategic directions of rural revitalization and an important part of building a digital China. The General Secretary pointed out that "developing the digital economy is a strategic choice to seize the opportunities of the new round of technological revolution and industrial transformation, promote the deep integration of the digital economy and the real economy, advance digital industrialization and industrial digitization, and empower the transformation and upgrading of traditional industries" [3]. This is a major strategic deployment of the Party Central Committee with Comrade Xi as the core for the development of the digital economy. It also points out the way forward for improving urban-rural relations in the new era and empowering the integrated development of urban and rural areas with the digital economy. Its core value is reflected in the following three aspects:

Efficiency improvement and transparency driven by technology: The application of technologies such as blockchain and big data has addressed issues of information isolation and trust deficiency in traditional land circulation. According to survey data, 78% of people believe that the biggest difficulty in current land circulation is the lack of stability and security. Due to the uncertain credit level of transaction counterparties, the risk of land circulation increases. Therefore, it is necessary to utilize blockchain, big data, and other applications to break the information barrier between transaction parties, allowing them to fully understand each other and ensuring

transaction safety and stability.

Resource integration under a multi-party coordination mechanism: Applying digital platforms to land circulation services is a necessary method to empower rural land circulation in the digital economy. Digital platforms integrate governments, village collectives, financial institutions, and market entities to form a benefit-sharing network, promoting the development of "three synergies."

Risk prevention and sustainable development: The application of big data analytics and cloud computing enables real-time monitoring and forecasting of the land circulation market, providing a scientific basis for policymakers and market participants. The use of blockchain technology ensures the immutability of data during the land circulation process, enhancing transaction security and credibility [4].

1.2. Research significance

This study focuses on the interactive mechanism of policy support, technology empowerment, and multi-party collaboration, systematically analyzing the construction path and operational logic of the land circulation platform. It holds dual value. Theoretically, it can expand the innovative path of land system reform in the context of rural revitalization, providing a new perspective for the integration of the "digital countryside" and "separation of three rights" theories. Practically, it extracts replicable platform construction experiences, such as the Heshan model and Yuzhong practice, providing decision-making references for optimizing rural resource allocation, promoting farmers' income, and agricultural modernization.

Through case studies and mechanistic deconstruction, this research aims to provide systematic solutions for solving the "last mile" problem of land circulation and promoting the implementation of the rural revitalization strategy.

1.3. Research objectives

The report of the 20th National Congress of the Communist Party of China clearly states that priority should be given to the development of agriculture and rural areas, accelerating the construction of a powerful agricultural country, and solidly promoting the revitalization of rural industries, talents, culture, ecology, and organizations. It also emphasizes the need to accelerate the construction of a modern economic system, focus on improving total factor productivity, and enhance the resilience and security of industrial and supply chains [5]. In recent years, despite significant progress in the expansion of land circulation in China, it still faces challenges such as uneven land prices, low credibility of some transaction entities, and pressure on resource and environmental carrying capacity, reflecting the insufficient resilience of the rural land circulation industry chain.

The role of the platform economy in economic and social development is increasingly prominent. In 2019, the State Council issued the "Guiding Opinions on Promoting the Standardized and Healthy Development of the Platform Economy," pointing out that "the Internet platform economy is a new organization of productive forces and a new driving force for economic development," which plays an important role in optimizing resource allocation, promoting industrial optimization and upgrading, and increasing employment [6]. In the era of digital economy, how to leverage the role of platforms to promote farmers' income growth is an important topic for achieving common prosperity. Therefore, the research objectives of this study are to clarify the construction path and optimize the operational mechanism. Based on the interactive logic of policy support, technological empowerment, and multi-party collaboration, top-level design will be conducted for the digital economy to empower integrated urban-rural development from a holistic perspective, guiding the in-depth advancement of the digital economy in the process of integrated urban-rural development from top to bottom [4].

2. Realistic foundation and dilemmas of rural land circulation platform construction

2.1. Analysis of the current situation of rural land circulation

2.1.1. Realistic dilemmas of rural land circulation

Through investigation and research, it is found that the current bottlenecks in the construction of land circulation platforms mainly include the following aspects:

(1) Insufficient policy awareness: Many farmers lack understanding of land circulation policies, leading to an underestimation of land resources.

(2) Legal implementation vacuum: The definition of rights, such as the mortgage and guarantee of contracted management rights, is ambiguous, and new models such as land valuation and shareholding lack implementation details, resulting in laws lagging behind practice.

(3) Lengthy approval process: Land circulation projects are often delayed or even fail due to lengthy approval processes. For example, the revitalization of homesteads requires approval from multiple departments, taking up to 278 days, and the project abortion rate is as high as 43%.

(4) Inadequate market mechanism: The market mechanism for land circulation is imperfect, with a lack of effective information matching mechanisms between supply and demand, and an incomplete pricing mechanism for circulation, putting farmers at a disadvantage in pricing.

(5) Lagging information platform construction: The construction of land circulation information platforms is lagging, lacking unified standards and norms, resulting in incomplete platform functions and poor user experience.

2.1.2. Statistics on rural land circulation disputes

There are various reasons for land transfer disputes. Li searched the cases of rural agricultural land transfer disputes from 2020 to 2024 in the Peking University Legal Information Network judicial case database and found that disputes caused by operator defaults accounted for up to 65%. These disputes can be roughly divided into two categories: operators defaulting on rent and operators privately changing the use of land. Among them, disputes caused by operators defaulting on rent account for about 57%, and disputes caused by operators privately changing the use of land account for about 7%. Disputes caused by farmers or village collectives defaulting account for about 17%, and disputes caused by unclear contract agreements between the two parties account for about 13% [7].

Lagging circulation mechanism in the western region: The western region of China has a limited number of intermediary agencies and lacks robust third-party market institutions. This leads to inadequate standardization, poor service effectiveness, low circulation efficiency, and the existence of independent negotiation and pricing in the actual circulation process [8].

Weak ability of farmers to protect their own interests: The circulation of land through village collectives or other informal organizations is relatively common. However, farmers lack the ability to negotiate for compensation benefits in land circulation. The confirmation of circulation duration and compensation standards is relatively passive [9], resulting in damage to farmers' interests.

2.2. Necessity of platform construction

2.2.1. Policy orientation

The policy orientation for the construction of this platform mainly focuses on the reform requirements for the market-oriented allocation of land elements. The 2025 Central Document No. 1 emphasizes improving the element guarantee mechanism, clarifying that land transfers must follow the principle of voluntary compliance

with the law, and stabilizing transfer fees through price index regulation to balance farmers' rights and agricultural competitiveness. This provides a solid policy foundation for our platform construction.

2.2.2. Practical needs: Increasing farmers' income and pursuing large-scale agricultural operations

Firstly, land is a critical element for rural industrial development, and large-scale operations can greatly improve the utilization rate of agricultural land. Through technology introduction and mechanized production, agricultural specialization can be strengthened, thereby freeing up more rural surplus labor to engage in secondary and tertiary industries in rural areas. Based on the industrial chain, this approach aims to enhance the multiple functions of agriculture, enrich the diverse values of rural areas, and promote the integrated development of rural industries.

Secondly, the competitive and intensive economic model brought about by large-scale land operations can expand and enrich the subjects of industrial integration by attracting capital investment, reducing agricultural production costs, and improving agricultural technology training services.

Thirdly, large-scale land operations can promote the integration, penetration, and cross-reorganization of agriculture with secondary and tertiary industries. This continuously stimulates the advantages and interests connections among different rural industries, enabling the agricultural industry to resist market risks and secure a favorable position in market competition.

Fourthly, in the context of urbanization, a large number of rural laborers have shifted to non-agricultural industries. Besides increasing their income through work, farmers can also obtain income from the circulation of land management rights.

2.2.3. Realistic demands: Unbalanced development of regional land circulation

The development of land circulation in central and western China is lagging, with a much lower degree of marketization compared to the eastern region. In the central region, the main forms of land circulation are government-led land acquisition and leasing. Due to the large proportion of the agricultural population in some provinces, land circulation is primarily used to expand agricultural production. In the western region, where most of the land area is vast and sparsely populated, there is a serious problem of blind land circulation, resulting in low efficiency of land resource utilization. However, the exploration and development of ecological agriculture, circular agriculture, and organic agriculture provide new directions for land circulation in the western region [10].

2.3. Bottlenecks in current platform construction

2.3.1. Inadequate legal norms and imperfect security system

Current laws and regulations fail to provide detailed provisions and guidance for the specific operations of land circulation, such as the prerequisites, scope of application, subject status, rights and obligations, transferee qualifications, and income distribution in collective land circulation. The lack of necessary legal provisions and clear and explicit regulations can lead to excessive operational arbitrariness and cause disputes over rights and interests. The local security system is inadequate, with issues such as untimely employment arrangements, arrears in subsidy payments, and unreasonable compensation, which severely weaken farmers' willingness to circulate land. The rural information exchange mechanism and circulation market mechanism are not perfect, resulting in low reference ability, limited selection space, and restricted circulation scope for land transfers. The quality of the land obtained is difficult to guarantee, hindering the development of the land circulation market [11].

Lack of supervision and inadequate evaluation system: Some regions have seen illegal occupation and transfer of land in the name of land circulation. This behavior not only severely disrupts the order of the land

market but also harms the immediate interests of farmers [12].

2.3.2. Weak technical support and service system

Inadequate application of digital tools: Currently, there are various websites related to land circulation on the market, commonly including Nongdiquan, Tuliu.com, and Zhonghualiang.com. Although platforms such as Tuliu.com have developed tools like farmland valuation systems and GPS mu measuring instruments, most county-level platforms still rely on traditional management methods and lack intelligent risk assessment and pricing models.

Poor integration of financial services: The integration of land circulation and financial services is relatively low, and financial institutions face difficulties in quickly approving loans due to the lack of credible data.

3. Theoretical framework: Construction of a three-dimensional driving model of "policy-technology-collaboration"

3.1. Theoretical basis

3.1.1. Policy tool theory

The study of policy tools emerged in the Western world in the 1980s, and its research achievements mainly include "The Tools of Government: A Guide to the New Governance" [13], edited by Lester M. Salamon and others. Policy tools refer to the general term for various means that public policy subjects can adopt to achieve public policy goals.

Salamon believes that policy tools have four inherent characteristics: coerciveness, directness, autonomy, and visibility. Howlett and Ramesh divide policy tools into voluntary tools, mixed tools, and coercive tools based on the degree of government involvement in the provision of public goods and services. The core of policy tool research is "how to turn policy intentions into management actions and policy ideals into policy realities" [14].

Therefore, based on the classifications of Salamon [13] and Howlett and Lodge [15], this paper deconstructs China's land transfer policy tools into three categories: authoritative, incentive, and informative, corresponding to the legitimacy, dynamism, and synergy dimensions of policy support.

3.1.2. Digital governance theory

Digital governance theory is a new quasi-paradigm of public management theory that combines governance theory with Internet digital technology. Its representative figure is the British scholar Patrick Dunleavy [16], who advocates the continuous application of digital technologies such as big data and cloud computing to public governance, based on the decline of the New Public Management movement and the rise of digital governance in the digital age. Domestic research on digital governance theory began with Professor Zhu Qianwei's book *Public Administration Theory* [17] in 2008.

Some studies have pointed out that digitization is the process of converting analog data into computer-readable data, providing important technical support for the government to provide intelligent services for people's livelihoods. Datafication, on the other hand, involves recording and analyzing all quantified social phenomena, allowing the government to fully tap into the technical potential of comprehensive big data quantification, achieve a panoramic trace and datafication of governance behaviors, reshape government management processes through information technology, improve efficiency and service quality, and ultimately achieve good governance. Therefore, based on digital governance theory, this paper constructs a dual-track structure of "core-auxiliary" technology for land transfer, empowering the land transfer process through technological transparency, decentralization, and precision. It reveals how technological innovation can reshape the land factor market through

the triple mechanism of "data-driven, process reengineering, and trust-building."

3.1.3. Collaborative governance theory

Collaborative governance theory is an emerging theory that intersects the synergetic theory from natural science with governance theory from social science. It is characterized by the diversification of governance subjects, the synergy of various subsystems, the coordination among self-organizing entities, and the formulation of common rules. It emphasizes finding ways to differentiate and integrate among conflicting forces to continuously optimize governance effects [14]. Based on collaborative governance theory, Ansell and Gash [18] proposed that multiple entities achieve public value through institutionalized negotiation and matching of rights and responsibilities. The essence of collaborative governance in land circulation is to integrate dispersed entities into a "community of interests" through institutionalized interactions, which is reflected in the formation of a clear collaboration network of rights and responsibilities among the government, market, and farmers, thereby avoiding "government monopoly" or "market failure."

3.2. Analysis of the three-dimensional driving model

3.2.1. Policy support dimension: Central policy guidance and local supporting system design

Policy tool theory [13] suggests that governments achieve policy objectives through a combination of authoritative, incentive, and informational tools. Based on this theory, this paper constructs a "tool-dimension" correspondence model to reveal the multi-level support logic of land circulation policies. Howlett and Lodge's [15] trichotomy is applicable to land circulation policy analysis. Authoritative tools such as the right confirmation system and use control provide legitimacy support, clarifying rights and responsibilities through legal and administrative coercion. Incentive tools like circulation subsidies and tax incentives form dynamic support, mobilizing participation enthusiasm. Informational tools, including trading platforms and data sharing, strengthen collaborative support, reducing information asymmetry and transaction costs.

In implementing land circulation policies, authoritative tools provide a legitimacy framework and stability guarantee for circulation behaviors through mandatory and standardized system design. Central policies establish a legal framework and grant legitimacy to circulation through reforms like the "separation of three rights" and the confirmation and registration of contracted land rights proposed in the 2016 "Opinions on Improving the Measures for the Separation of Rural Land Ownership, Contracting Rights, and Management Rights" [19]. Local governments convert abstract policies into operational institutional arrangements through supporting implementation details. For example, Chengdu first introduced a "negative list" in 2014 and established a "circulation access negative list" and risk guarantee fund system in the 2017 "Measures for the Administration of Rural Land Management Rights Circulation in Chengdu (Trial)" [20]. These tools utilize public power endorsement to strengthen policy execution, with the core function of reducing transaction uncertainty and avoiding contractual disputes or rights infringements due to ambiguous rules, thereby laying an institutional foundation for market mechanism operation.

Firstly, the financial subsidy mechanism is subdivided into direct subsidies, which provide tiered incentives to large-scale operators such as family farms and cooperatives based on the transferred area; and indirect subsidies, which reduce operating costs through agricultural insurance premium subsidies, agricultural machinery purchase subsidies, etc. Targeted policy guidance for land transfer is provided by introducing subsidy policies that encourage land circulation, changing the relative prices of factors, correcting market failures, continuously improving subsidy policies, and balancing the long-term goals of land circulation and large-scale operations.

Secondly, the financial support system includes property financing and risk-taking, launching management right mortgage loans, establishing a government financing guarantee system, and providing risk compensation for

new agricultural entities.

The policy tool theory reveals the multidimensional support logic of land transfer policies. Central policies build the institutional foundation through authoritative tools, while local policies rely on incentive-based and information-based tools to optimize implementation efficiency, forming a collaborative governance path of "top-level design-local adaptation" and promoting a trinity of "system-market-technology" governance. This framework provides a theoretical basis for the refined design of land transfer policies.

3.2.2. Technical empowerment dimension: Core technology and auxiliary technology architecture

The Third Plenary Session of the 18th CPC Central Committee proposed the modernization of the national governance system and governance capabilities. The "14th Five-Year Plan" period is a critical time for China's industrial economy to move towards a digital economy, posing new requirements for the development of the big data industry, which will enter a new stage. Digital technologies in fields such as the Internet, the Internet of Things, and cloud computing have been widely used in various aspects such as government governance, enterprise management, and media promotion, effectively realizing the innovative development of digital technology in various fields of society. The in-depth application of government department data resources is giving rise to data resource management, which requires governments at all levels to actively adapt to the development of the information age and innovatively use digital technology in governance to achieve open sharing of government information.

Based on digital governance theory, a "core-auxiliary" dual-track technology framework can be constructed in the field of land circulation to analyze how technological innovation reshapes the land factor market through the triple mechanism of "data-driven, process reengineering, and trust building." Among them, core technologies such as GIS and blockchain primarily address the issues of property rights definition and transaction credibility, forming a basic structure of "spatial rights confirmation and digital deposit"; auxiliary technologies such as big data and the Internet of Things focus on market operation and regulatory optimization, building an enhanced system of "value discovery and status monitoring."

Research has found that GIS and blockchain technology form the foundation of digital rights confirmation, improving the efficiency of property rights registration, while big data and Internet of Things technology optimize market operations and increase the success rate of circulation matching. The empowerment of core technology greatly improves the efficiency of land circulation governance, reduces administrative costs, increases market transparency, increases the number of online transactions by new business entities, and enhances participation.

3.2.3. Multi-party collaboration dimension: Government regulation, market entity participation, and farmer organization path

Based on the theory of collaborative governance, this paper constructs an institutionalized collaboration framework for the ternary subjects of "government-market-farmers" in land circulation, revealing how multiple subjects can achieve dual improvements in resource allocation efficiency and fairness through institutionalized interactions.

Firstly, at the government level, in land circulation governance, the government fulfills the functions of institutional supply and ultimate supervision through a dual-track mechanism of "rule-making and service innovation." At the institutional supply level, the Ministry of Agriculture and Rural Affairs issued a unified national template for circulation contracts in 2021 and established a legal framework for the "separation of three rights" through the revision of the Rural Land Contracting Law in 2018 [21], clarifying the legality of management right mortgages and laying the institutional foundation for the marketization of land factors. At the service innovation level, Zhejiang Province has innovated the "agricultural land code" system, enabling "one-code traceability"

of information such as land ownership and circulation records, driving a 63% decrease in the rate of disputes over rights confirmation. The government's role is transitioning from a traditional manager to a "rule designer + service provider," providing systematic guarantees for the standardized development of the land circulation market through the dual empowerment of standardized institutions and digital tools.

Secondly, at the market level, market entities activate market momentum through technological innovation and financial instruments in land circulation, forming a dual-wheel drive model of "platform operation + financial empowerment." In terms of platform enterprises and financial institutions, they have simultaneously innovated service models. For example, China Construction Bank has launched the "land mortgage cloud loan" product, which utilizes big data risk control to achieve rapid credit authorization within 3 minutes, with cumulative loans exceeding 80 billion yuan. These two types of entities work together to discover the true value of land through a market-based bidding mechanism and resolve transaction risks through financial instruments, jointly building a balanced "efficiency-safety" land factor market system.

At the farmer level, the farmer organization has formed a multi-level and multi-dimensional collective action model through institutional innovation and technological empowerment. For example, the reform of "confirming rights, shares, but not land" in Jiaxing, Zhejiang, focuses on land demutualization, converting 78% of the contracted land in administrative villages into equity. Farmers receive dividends based on their shares while retaining unified management rights for the village collective, solving the problem of land fragmentation.

These practices indicate that organizational innovation significantly improves farmers' market bargaining power and resource allocation efficiency through triple mechanisms of property rights reconstruction, collective action, and technological empowerment.

3.3. Land circulation practice based on a three-dimensional coordination model: A case study of Deqing County, Zhejiang Province

3.3.1. Case background and policy framework

As one of the first rural reform pilot zones in China, Deqing County, Zhejiang Province, has implemented a land circulation practice centered around a three-dimensional coordination model of "government leadership-market drive-farmer participation." Guided by the provincial policy "Digital Village Construction Action Plan of Zhejiang Province" [22], Deqing County issued the "Regulations on Digital Transaction Management of Rural Property Rights (Trial)" [23], which clearly mentions three key provisions: (1) Electronic Contract Effectiveness: Article 8 stipulates that "electronic contracts stored on the blockchain have the same legal effect as paper contracts," addressing the compliance issues of online transactions. (2) Property Registration Standards: Article 12 requires the use of "0.1-meter accuracy GIS survey data as the basis for property rights confirmation," ensuring the authority of spatial data. (3) Collaborative Governance Mechanism: Article 15 establishes a tripartite responsibility list of "government supervision + third-party evaluation + village collective coordination."

3.3.2. Three-dimensional driving model

The geographic information town in Deqing County has become the place with the highest concentration of geographic information enterprises in the country. Through the deep integration of geographic information and blockchain, the use of drone aerial surveying and ground RTK positioning technology has completed the digital surveying of 123,000 land parcels in the county, with an average error of ≤ 0.1 meters, forming a "one parcel, one QR code" identification system. Relying on the "Deqing Geographic Information Brain" platform, the dynamic correlation between land attributes and spatial data is achieved. Utilizing a blockchain smart contract system, 12

types of smart contract templates have been deployed on the AntChain agricultural rights platform, automatically executing functions such as rent payment and renewal reminders.

Under the tripartite collaboration mechanism, institutionalized interactions among multiple entities are facilitated. The government adopts a dynamic regulatory mechanism, connecting to the "Land Survey Cloud" of the Ministry of Natural Resources to conduct quarterly remote sensing monitoring of circulation projects over 500 acres. In 2018, the "Deqing County Rural Property Rights Evaluation Center" was established, formulating the "Regulations on the Evaluation of Land Management Rights Value" [24]. This adopts a dual-model pricing approach using the income method and the market method, improving the land valuation mechanism. Additionally, a "Villagers' Discussion Hall" system has been established, supporting online proposals, electronic voting, and blockchain-based tamper-proof result postings.

4. Design of the construction path for the rural land circulation platform

4.1. Construction principles and objectives

4.1.1. Fairness

In today's social transactions, there is information asymmetry and relative inequality between individuals and businesses, individuals and governments, as well as businesses and governments, which are also unavoidable in the process of land circulation. Therefore, in the construction of the rural land network platform, it is necessary to protect multiple entities such as farmers, village collectives, and enterprises, develop standardized processes, ensure transparent transaction information, and comprehensively consider the differences in development levels among various regions to establish different transaction standards. This approach is conducive to avoiding damage to the legitimate interests of vulnerable groups to a certain extent.

4.1.2. Efficiency

In the process of land circulation, spatial obstacles are created for farmers, businesses, and relevant departments, reducing the work efficiency of all parties. The construction of this platform aims to utilize high technologies such as blockchain and big data to build intelligent information matching, promote a "one-stop" service model, reduce circulation costs, improve service quality, and break spatial restrictions, thereby enhancing work efficiency in the process of land circulation transactions.

4.1.3. Sustainability

Land circulation is an essential path for China's era of development and economic progress. The construction of this platform should be based on promoting healthy and sustainable land circulation, which is not only related to economic and trade aspects but also closely linked to ecological environmental protection. Through the platform's monitoring and evaluation systems, land quality and ecological safety can be ensured, facilitating secondary land circulation. Additionally, the platform's risk prediction system enables both transaction parties to make informed decisions based on clear risks, which is conducive to establishing friendly relationships among all parties, creating a positive and healthy cooperative atmosphere, and promoting the sustainable development of land circulation transactions.

4.2. Key technical support paths

4.2.1. Digitization of land information

Through remote sensing and mapping technology, basic data such as the geographical location, area, and usage of

land can be efficiently obtained. Combined with the construction of ownership databases, comprehensive digital management of land information can be achieved. Furthermore, by building a unified land circulation reserve database and entity information database, information such as the transportation location and industrial association of land parcels can be integrated into the database, providing data support for circulation supply and demand matching [25].

4.2.2. Hybrid model design of "platform + village service station"

A hybrid model of "platform + village service station" is established. The platform is primarily responsible for information management and transaction matching, while the village service station serves as a grassroots service network, providing farmers with one-stop services [26] such as policy advice, information release, and contract signing. As the core carrier of informatization, the platform mainly undertakes the following functions: (1) information release; (2) transaction matching; (3) price evaluation; (4) dispute resolution [27].

The village service station, as a grassroots service site, mainly undertakes the following responsibilities: policy promotion through village websites, farmers' mailboxes, and other means to disseminate land circulation policies and regulations; business guidance to provide farmers with guidance services for land circulation contract signing and attestation; and information collection to gather village-level land circulation demand and supply information and report it to the platform in a timely manner.

5. Optimization of platform operating mechanisms

Rural land circulation is an important means of promoting agricultural modernization and rural revitalization. Optimizing the operating mechanism of the land circulation platform is significant for improving the efficiency of land circulation and protecting farmers' rights and interests. The sustainable development of the rural land circulation platform relies on a scientific and reasonable operating mechanism design.

5.1. Motivational mechanism

The motivational mechanism is the core factor that drives the development of the rural land circulation platform, and it can also promote farmers' willingness to circulate, mainly through government policy incentives.

As an important promoter of rural land circulation, the government can reduce circulation costs and increase participation enthusiasm through financial subsidies, tax relief, loan interest subsidies, and other methods. Specific measures include:

Firstly, direct subsidies: Provide one-time or annual subsidies to farmers who participate in land circulation, such as a subsidy of 200–500 yuan per mu, to encourage long-term circulation rather than short-term leasing;

Secondly, project support: Provide policy support to large-scale circulation entities and enterprises that provide land circulation services;

Thirdly, tax relief: Reduce or exempt taxes for enterprises rooted in agriculture and providing land circulation services.

5.2. Safeguard mechanism

The safeguard mechanism aims to ensure the legitimacy, safety, and stability of land circulation, protecting the legitimate rights and interests of both parties involved in the circulation and ensuring the safety of funds and land use. It mainly includes legal protection, data security, government support, institutional guarantees, and other aspects.

5.2.1. Legal safeguards

Building a legal platform for rural land circulation can promote the circulation of idle land and improve resource utilization efficiency. On the other hand, combining law with land circulation essentially means using legal weapons to protect the safety of land circulation. Lawyers on the legal platform use their professional knowledge to ensure the interests of both parties. This can prevent transaction disputes from arising at their source, but it does not necessarily mean that transaction disputes will not occur. Therefore, it is still necessary to adopt relevant legal safeguards to ensure the stability and safety of transactions.

5.2.2. Data security guarantee

Data security is primarily reflected in the protection of farmers' privacy, achieved through the use of blockchain technology to ensure data tamper-proofing. Sensitive information such as farmers' ID numbers, bank card numbers, and other personal information undergoes desensitization treatment.

5.2.3. Government support and institutional guarantee

Policy support and institutional guarantees are crucial backbones for optimizing the operational mechanism of the land transfer platform. Government departments play a vital role in the collaborative mechanism. On one hand, the government needs to formulate clear policies and regulations to provide legal protection for land transfers; on the other hand, it also needs to offer services such as policy consultation, contract guidance, and price evaluation. For instance, Tianmen City has clarified the principles of legality, voluntariness, and compensation, and established a land information disclosure system, contract management system, and dispute resolution system. The formulation of this policy helps to protect farmers' rights and interests and promotes the standardized development of land transfers.

Therefore, to actively promote land transfer work and improve the function of publishing and inquiring about land transfer information, the government should leverage its authority to promptly release relevant policies and regulations, enhancing the safety and health of the land transfer trading market [28].

5.2.4. Service guarantee

The service quality of the land transfer platform relies on the professional capabilities of the service personnel. Therefore, strengthening the training of relevant personnel is an essential aspect of optimizing the operational mechanism. For example, Jiangxi proposes to strengthen construction in terms of both software and hardware, including training for relevant personnel [29]. To establish a legal service platform for land transfers, enterprises should focus more on their own services, improve the professional quality of their workforce, enhance their service philosophy, carry out professional knowledge training activities, and allow lawyers to serve both parties to the land transfer with higher professional quality, thereby enhancing customers' service experience.

5.3. Collaborative mechanism

5.3.1. Collaborative cooperation

Multiple entities land transfers involve multiple entities such as farmers, village collectives, enterprises, and government departments. The collaborative mechanism needs to clarify the responsibilities of all parties and promote cooperation, requiring the construction of a multi-dimensional collaborative operational system [29] to ensure information symmetry and accuracy, and improve the enterprise's ability to predict and manage future markets, primarily by achieving data sharing across departments.

5.3.2. Collaborative advancement of technical support and innovation

Technical support is a vital driving force for the collaborative mechanism. By introducing technological means such as big data and artificial intelligence, the efficiency and transparency of land transfers can be improved. For instance, the "Internet +" rural land transfer trading platform reduces investment costs and improves transfer efficiency through supply and demand matching and precise pricing.

6. Empirical analysis: Typical case studies

6.1. Comparative analysis of cases

Table 1 shows the cases for comparative analysis.

Table 1. Comparative analysis of cases

Dimension	Guangxi Nanning Land Transfer Trading Center	Chongqing Land Trading Platform	Chaogou Village Land Transfer Dispute
Policy Implementation	The Nanning Center utilizes various media platforms such as WeChat public accounts, Douyin (TikTok), Kuaishou, news outlets, and "three-level" WeChat groups at the district, town, and village levels to strengthen online promotion, allowing the masses to learn more detailed information. Additionally, the trading center vigorously promotes rural property rights transfer and trading policies by holding meetings such as town and village cadre conferences and mass representative meetings, organizes training on rural property rights transfer and trading, and distributes promotional materials during visits to towns, villages, enterprises, and farmers.	Chongqing has formed a unique land ticket system with the "Administrative Measures for Land Tickets in Chongqing" as the general guideline, and "voluntary reclamation, open trading, income returning to farmers, direct payment, and use according to regulations" as the core content.	Utilize laws and regulations to participate in land circulation.
Technology Adoption	Based on existing trading varieties, innovative trading varieties have been introduced, and a system of rural brokers has been established. Through the "rural property rights circulation + finance" cooperation model, a cooperation agreement has been signed between the Agricultural Bank of China Nanning Branch and the Nanning Agricultural and Rural Bureau. A cooperation agreement for dispute resolution and arbitration has also been signed with the Qingxiu District Agricultural and Rural Bureau, establishing a friendly cooperative relationship for the resolution and arbitration of rural land contracting and management rights disputes, and jointly carrying out dispute resolution and arbitration work with the Qingxiu District Agricultural and Rural Bureau.	We actively promote the realization of electronic transactions and develop a land ticket transaction management system to "let data do more work and reduce the need for people to travel." We also promote data correlation in various aspects of land ticket transactions to ensure traceability of their source and destination, facilitate transparent and open transactions, and protect farmers' right to know about policies.	It is not explicitly introduced.
Multi-party Coordination	By constructing a four-level service network platform consisting of 42 township service stations and 797 village-level service offices, the goal of "reducing the need for rural residents to travel and providing zero-distance service" for rural property rights transactions has been achieved, promoting the extension of standardized transaction services to rural areas.	Gradually establish a supply-demand coordinated price-volume regulation mechanism, and organize transactions through listing and auction methods.	Although the village committee was involved, it was only responsible for land circulation issues and did not consider aspects such as company operations and land restoration. As a result, only judicial means were used to resolve issues after they arose.

Table 1 (Continued)

Dimension	Guangxi Nanning Land Transfer Trading Center	Chongqing Land Trading Platform	Chaogou Village Land Transfer Dispute
Management Measures	The trading center has signed a cooperation agreement with the Qingxiu District Agricultural and Rural Bureau to establish a friendly cooperative relationship for dispute resolution and arbitration related to rural land contracting and management rights. By jointly carrying out dispute resolution and arbitration work with the Qingxiu District Agricultural and Rural Bureau, the trading center aims to promote the development of friendly relationships between the government and enterprises in Qingxiu District, further improve the dispute resolution mechanism, and protect the legitimate rights and interests of both parties involved in transactions.	A "1+10" land ticket system framework has been formed, with the land ticket management measures as the overall guidance, covering various aspects of reclamation, trading, and use.	Use contracts and legal provisions to restrict companies from defaulting on payments.
Outcomes	A new model of "online promotion + four-level service + financial collaboration" has been explored. In 2023, 524 pre-listed circulation projects were completed, covering a land area of 94,566.71 mu and involving an amount of approximately 1,463.6862 million yuan. A total of 39 demand information were released, and 214 projects were successfully transacted, including 45 through bidding and 169 through agreement. The total transaction area was 45,657.05 mu, and the total amount of rural property rights circulation transactions was 795 million yuan, an increase of 84.45% compared to the previous year.	By the end of 2022, the organization had facilitated transactions of rural physical land property rights involving 1.1277 million mu of land with a total value of 4.085 billion yuan, and had carried out rural property rights mortgage financing transactions covering 110,200 mu of land with a total value of 1.987 billion yuan. In addition, the Chongqing Land Exchange also piloted trading of rural collectively-owned land for commercial construction use, with 3,380 mu of land transacted for a total of 1.177 billion yuan. Seven secondary market transactions of state-owned land for construction use were organized, involving 124 mu of land and totaling 64.8735 million yuan.	Kangbeiyuan Company failed to fulfill its obligation to pay the rent arrears as agreed, and the village committee's attempt to claim it was unsuccessful, resulting in litigation. The court verdict states that Luoyang Kangbeiyuan Food Co., Ltd. shall pay the land rent of 1,644,191.91 yuan to the Chaogou Village Committee of Gaoshan Town, Yichuan County within 30 days after the verdict comes into effect.

6.2. Lessons and insights

6.2.1. Theoretical development

As can be seen from the above cases, policy and institutional regulations are indispensable. With correct theoretical guidance, a series of management regulations or related mechanisms can be developed according to the actual situation of each region and adapted to local conditions. For example, it is suggested to establish and improve a land circulation review mechanism involving the government, experts, and the market, with townships as the unit. This mechanism would conduct pre-qualification reviews of inflow entities and study and demonstrate the proposed leading industries. Alternatively, drawing from the experience of the Chongqing Land Exchange Platform, innovative systems such as the land ticket system can be created and continuously improved. The formulation of these policies should be scientific and accurate.

6.2.2. Keeping pace with the times

Drawing on the successful experiences of the previous two cases, in the current era of big data, it is an inevitable requirement to establish and improve trading platforms in various regions to ensure the orderly and standardized advancement of land circulation. A rural property rights trading system with hierarchical management at the

county, township, and village levels should be constructed. The function of the "land circulation module" should be improved, transaction tracking and supervision should be strengthened, and the operating procedures for land circulation should be standardized. This will achieve interconnected and real-time sharing of rural property rights circulation and transaction information within the city, promoting the standardization and intelligence of land circulation.

6.2.3. Multi-party collaborative management

Collaborating with multiple parties involves not only farmers and transaction parties but also government departments and judicial authorities to strengthen policy guidance and legal supervision of land circulation, similar to the establishment of a four-level service system in Nanning City. Additionally, by promoting cross-regional joint operations of village collective resources, integrating various resources such as land, technology, and labor, the management and use costs of individual village collectives can be reduced, resource utilization efficiency can be improved, collective resource benefits can be realized, and villagers' income can be increased. Firstly, through cross-village cooperation, natural resources such as land, water, and forests in adjacent areas can be integrated to expand the benefits of resource utilization. For example, multiple village collectives can collaborate on land circulation to jointly develop modern agricultural projects, achieving mechanization and scale agriculture. Regional integration of resources can also provide broader space for infrastructure construction and industrial planning, contributing to the optimal allocation of regional resources. Secondly, relying on rural cooperatives or cross-village resource sharing platforms, sharing and cooperation in production factors such as technology and labor can be achieved, further enhancing resource management efficiency.

7. Response measures and outlook

7.1. Response measures

7.1.1. Developing platform management policies

With the development of the big data era, land transfer trading platforms are continuously emerging. New land transfer methods are related to the fundamental rights and interests of farmers. Therefore, when developing regional land transfer platform management policies, it is necessary to improve rigor and scientificity by strengthening the investigation of the actual situation of existing policies and systems, operational status, and the degree of matching with new policies in the region.

Firstly, develop terms of rights and responsibilities to clarify the duties of all parties. For example, the work positioning, functional responsibilities, scope of authority, work guarantees, daily operations, and connections with other systems of governments at various levels, such as county and township governments, should be further clarified and specifically divided to provide theoretical support for governments at all levels to leverage their professional advantages in service, supervision, and management from the policy level.

Secondly, clarify the specific content of land transfer platform management policies, standardize land transfer contracts and procedures, and clarify approval and registration processes. In particular, the content of land transfer contracts should specify details such as the transfer period, transaction method, land grade, land location, ownership of planting subsidies, and the rights and obligations of land contractors and land managers. This will effectively reduce the conflicts of interest between land contractors and land managers after land transfer and facilitate conflict resolution and dispute settlement.

Thirdly, improve and strengthen the communication and liaison mechanism between the land transfer

platform management policies and other policies. Close cooperation and interactive communication among relevant institutions are required, especially in professional fields such as agricultural financial services and the construction of land transfer property rights trading markets. By establishing or improving new models of communication and information sharing, information transmission efficiency will be improved, which is conducive to risk warning and prevention in land transfers, thus providing support for the operation of land transfer platforms.

7.1.2. Improving the functionality of the land transfer trading platform

Based on research conducted on existing online platforms, it has been found that the rural property rights trading platform authorized by the government possesses advantages such as a clear platform layout, rich functional modules, and impartial and objective information. However, there are still some drawbacks, including low information timeliness, difficulty in obtaining timely and accurate symmetrical information, and varying degrees of information development among different local governments. On the other hand, rural land property rights transfer platforms established by enterprises, such as Tuliu.com, Soutudi.com, and Tudiziyuan.com, offer easy access to services and have a wide range of service areas. Nevertheless, these enterprise platforms still face challenges in verifying information authenticity and provide limited service options. In this regard, we can combine the strengths of both types of platforms by fostering cooperation between the government and enterprises. In terms of trading functionality, the addition of intelligent voice AI that supports various dialects would facilitate users' search for relevant applications based on their needs. Furthermore, a policy news and legal service application function can be integrated into the network platform.

7.1.3. Innovating synergy mechanisms

Establishing a "1+N" training system involves creating a policy teaching video on the platform. Led by the government and utilizing scientifically correct methods, superior authorities can directly explain policy news comprehension and relevant professional knowledge, such as contract law, to eliminate misunderstandings. Setting up N teaching scenarios and mobilizing relevant personnel and professionals to conduct training and explanation in fields and rural areas will ensure the correct implementation and understanding of policies.

7.2. Future prospects

In recent years, research on the environmental impact of land transfers has gradually increased. Some scholars believe that land transfers can promote large-scale and intensive production, rapid development of agricultural modernization, and increase fertilizer pollution on land. Additionally, the impact of land transfers on agricultural carbon emissions varies by region. Other scholars argue that land transfers can reduce the intensity of agricultural carbon emissions and analyze the spatial spillover effects of land transfers on agricultural carbon emission intensity. Meanwhile, some scholars suggest that land transfers can positively impact the agricultural production environment. Nevertheless, it is undeniable that land transfers have brought about many environmental issues. Following China's policy guidance of "green mountains and blue waves are golden mountains and silver mountains" and "achieving carbon peak and carbon neutrality," low-carbon agriculture has become an ecological choice and trend of the times to address high-carbon agriculture. Therefore, as land transfers continue to develop in the future, integrating the land transfer platform with the low-carbon concept will jointly promote China's green, healthy, and sustainable development.

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