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Implementation Path and Effect Evaluation of Guangxi Rural Logistics Symbiotic Development System Based on Blockchain

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Abstract: There are some problems in the development of rural logistics in Guangxi, such as low efficiency, high cost and low information level. This paper first puts forward the implementation path of logistics symbiotic development system, analyzes the nodes and connections in the logistics network, as well as their relationship and interaction mode, and identifies key stakeholders and potential cooperation opportunities. Then, this paper conducts stakeholder analysis, identifies and evaluates stakeholders including government, logistics enterprises, farmers and consumers, and analyzes their needs, expectations and influence, so as to formulate fairer and more effective logistics policies. Then this paper evaluates the rural logistics policy environment in Guangxi, and discusses how policies affect the development of logistics system and how to promote technology application through policy guidance. The application of blockchain technology improves logistics efficiency and reduces operating costs. Specifically, the logistics time is reduced by nearly half on some routes, while the logistics cost is reduced by about 54% on average. The tamper-proof and traceable characteristics of blockchain technology enhance logistics management and reduce the loss rate of goods. Therefore, this study concludes that blockchain technology has great potential in the field of rural logistics, and can promote the development of rural logistics in Guangxi and even wider areas.

1. Introduction

Logistics industry has become a prominent force to promote regional economic development, especially in rural areas, which is an important support to realize rural revitalization strategy. However, rural logistics faces a series of challenges, such as weak infrastructure, low degree of informatization, high logistics cost and low efficiency. In this context, blockchain technology provides new ideas and tools for solving the problems of trust, efficiency and cost in rural logistics with its characteristics of distributed account books, unbreakable data and transparency.

This paper systematically analyzes the current situation and existing problems of rural logistics development in Guangxi, and proposes the implementation path of the rural logistics symbiotic

development system based on blockchain, providing theoretical support and practical guidance for the development of Guangxi and even wider regions.

The paper first introduces the research background and the research questions; secondly, it reviews related work and discusses related progress at home and abroad and the potential applications of blockchain technology; then it explains the research methods, including qualitative research, social network analysis and stakeholder analysis; and it presents the empirical research results, including social network analysis results, policy environment assessment and blockchain technology application effect evaluation; finally, it summarizes the research findings.

2. Related Work

Logistics is not only an important bridge connecting urban and rural areas, but also a key factor in promoting regional economic development. Based on an in-depth analysis of the current development status and shortcomings, Li et al. [1] selected the TOPSIS evaluation method based on entropy weight to evaluate the development status of rural logistics at the municipal and county levels from four dimensions: economic development, logistics scale, infrastructure, and degree of informatization. They further explored the difficulties and paths of rural logistics development and proposed optimizing service network functions, improving the layout of logistics infrastructure, and improving resource utilization efficiency. In view of the current slow development of rural logistics in China and the low efficiency of the rural logistics system, Xu and Wei [2] combined the national policies and conducted a study on the location selection of rural logistics centers using Fuyang, Anhui as an example, based on a thorough study and analysis of the current status of advanced research at home and abroad. Xu and Zhu [3] constructed a symbiotic evolution model between rural logistics and emerging diversified business formats, and conducted an empirical analysis using Changzhou as an example. The research results showed that Changzhou' s rural logistics industry and emerging business formats such as ecological agriculture and cultural leisure were in the early stages of mutually beneficial symbiotic evolution, and there was still room for further improvement. Zhu and Zhan [4] clarified the operation mechanism of the coupling coordination system of digital economy and rural logistics based on the theoretical framework of combining form-subject logic-operation level. By constructing an evaluation index system and a coupling coordination evaluation model, they demonstrated the coupling coordination relationship between digital economy and rural logistics in 21 provinces (autonomous regions and municipalities) in China. Based on the fact that rural logistics is an important bridge between rural areas and cities, Zhou and Liu [5] took the development of rural logistics in Gansu Province as the starting point, analyzed the current development status and problems of rural logistics in Gansu Province, and gave corresponding reasonable countermeasures to the problems.

Dovbischuk[6] conducted a study based on the dynamic capability framework (DCF) and relational perspective (RV). He collected data from 83 logistics service providers and 30 internal logistics departments through an online survey and used correlation analysis to determine the strength and direction of the relationship between latent variables. Hohenstein[7] captured the impact of COVID-19 on supply chain or logistics systems and explored different strategies and mitigation measures. Herold et al.[8] studied and analyzed how logistics service providers coped with the challenges brought by COVID-19 and extracted lessons from them. Santarek et al. [9] studied the factors that affect the effectiveness of reverse logistics activities in Vietnamese supermarkets. Butt et al. [10] analyzed the practices and effects of reverse logistics of retail companies in the circular economy through a multiple case study method. From the above research, we can see that the rural logistics field has shown the characteristics of diversity and complexity, both from the perspective of theoretical discussion and practical application. Blockchain technology,

with its characteristics of distributed ledger, data immutability and transparency, provides new solutions for the rural logistics field. This paper focuses on the implementation path and effect of the logistics symbiotic development system in Guangxi under the blockchain. Through the analysis of the current situation of rural logistics in Guangxi and combining the advantages of blockchain technology, this paper will propose a set of practical implementation paths and construct a corresponding effect evaluation model, in order to provide theoretical support and practical guidance for the development of rural logistics in Guangxi and even wider areas.

3. Method

3.1 Implementation Path

The implementation path of the Guangxi rural logistics symbiotic development system based on blockchain is as follows[11]:

Building a logistics network with the county-level logistics distribution center as the core. This center will serve as a hub for logistics, information flow and capital flow, responsible for coordinating and dispatching logistics activities throughout the county. Then, by establishing central township delivery logistics transfer stations and village-level delivery logistics comprehensive service stations, a logistics network covering the entire region will be formed to ensure that every natural village can enjoy express delivery services and every administrative village can achieve daily delivery of express delivery.

On this basis, relying on enterprises such as Guangxi Supply and Marketing Investment Group Co., Ltd. and China Post Guangxi Branch, we will build the main channels for rural e-commerce and express logistics. By strengthening the service capabilities of these enterprises, we will improve the level of e-commerce services in rural areas. At the same time, we will encourage more market players to participate in the construction of the three-level rural express logistics system at the county, township and village levels.

In order to further improve logistics efficiency, blockchain technology is used to establish a positive credibility ecosystem. Through the immutable and traceable characteristics of blockchain, transaction efficiency is improved, transaction costs are reduced, and consumer trust in products is enhanced.

Strengthening the role of the rural postal system, innovate the operating model of township postal outlets by strengthening the sharing of rural postal infrastructure and service networks, and enable them to undertake more rural public services, such as collection, agency and payment services.

3.2 Qualitative Research Methods

This paper studies and evaluates the practical application and effect of rural logistics system in Guangxi by qualitative research method [12-13]. Qualitative research can understand social phenomena and the key factors and trends of rural logistics system in Guangxi through non-numerical data collection and analysis. Data are collected through in-depth interviews, focus group discussions, field observations and document analysis, and then content analysis and thematic analysis are used to extract key themes and patterns from the collected data.

3.3 Social Network Analysis

In this study, a social network model of rural logistics is constructed to analyze the nodes and connections in the logistics network, as well as the relationships and interaction patterns between

them [14-15]. In this model, nodes can be physical locations such as logistics centers, distribution points, warehouses, or organizations and individuals involved in the logistics process, such as farmers, cooperatives, and logistics companies. The connections between nodes represent the flow of goods, information exchange, and capital flow in the logistics process. These connections can be direct physical transportation paths or channels for the transmission of information and instructions. This paper analyzes the relationship strength, cooperation frequency, and interaction stability between nodes, which includes the cooperation model, competitive relationship, and potential synergy between nodes. By calculating indicators such as the node's outbound edge probability, inbound edge probability, and directed mutual information, the role and function of the node in the network are evaluated. At the same time, the output information and input information of the node are combined, and the weight between the two is adjusted by a constant to comprehensively evaluate the importance of the node. In addition, the geographical location of the node has an impact on the cargo transmission path and the relationship between nodes. The distance between nodes is an important factor in evaluating the efficiency of the distribution system. This paper also evaluates the closeness of the distribution nodes. By calculating the closeness of each node, the importance of the node in the network is evaluated. Finally, the betweenness analysis of distribution nodes is also essential. It quantifies the betweenness of nodes, that is, the frequency of nodes acting as shortest path bridges in the entire network. The betweenness reflects the degree of participation of nodes in all shortest paths.

3.4 Stakeholder Analysis

This paper identifies and evaluates stakeholders including government, logistics enterprises, farmers and consumers, and analyzes their needs, expectations and influence.

The government is a policy maker and a market regulator. The government needs to promote the construction and development of rural logistics system through policy support and financial input, so as to realize the rural revitalization strategy. The government expects to provide favorable conditions for the coordinated development of rural logistics by improving rural logistics infrastructure, such as building rural roads.

The demand of logistics enterprises lies in improving logistics efficiency and reducing operating costs in order to enhance market competitiveness. Logistics enterprises expect to improve service quality and transparency and enhance consumer trust. The influence of logistics enterprises is that they can promote the circulation of products and the development of rural e-commerce by providing high-quality logistics services.

Producers expect to improve the market competitiveness of agricultural products. The demand of consumers lies in obtaining high-quality agricultural products with reasonable prices, and having a clear understanding of the source and circulation process of products. Consumers expect to enhance their trust and satisfaction with products through transparent logistics information.

4. Results and Discussion

4.1 Social Network Analysis Results

The results of social network analysis show that the deep integration of transportation and postal express delivery can effectively promote the emergence and development of a new model of rural logistics joint distribution. Under this model, a rural logistics joint distribution model with three-level transit between county, township and village is proposed to adapt to the special environment and needs of rural logistics distribution. This model establishes a shared information system for enterprises participating in rural logistics, integrates the scattered distribution data of

various enterprises, and realizes the unified allocation and joint distribution of goods. Specifically, the goods entering and leaving the county are first placed in the county-level rural logistics service center, and then uniformly allocated and jointly distributed to the township-level rural logistics service station or village-level logistics service point, or jointly delivered to the city-level logistics distribution center.

In this process, the three-level logistics resources, transportation vehicles, and distribution personnel are uniformly deployed, and each alliance enterprise undertakes part of the distribution task, realizing the intensive alliance operation mode of joint distribution of logistics in rural areas below the county level. This model not only improves logistics efficiency, but also reduces operating costs, and ensures that the interests of each participating entity are fairly and reasonably distributed through a reasonable interest distribution model. As shown in Table 1, the logistics efficiency and operating cost results of the intensive alliance operation model and the traditional model are as follows:

Table 1: Model comparison data

Logistics Route ID	Traditional Model_Logistics Efficiency (orders/day)	Traditional Model_Operating Cost (USD/order)	New Model_Logistics Efficiency (orders/day)	New Model_Operating Cost (USD/order)
Route 1	100	15	150	10
Route 2	80	18	120	12
Route 3	120	16	180	9
Route 4	90	14	140	11
Route 5	110	17	160	8

The study also found that the rural logistics joint distribution model with three-level transit between counties, towns and villages can adapt well to the development requirements of rural logistics. The benefit distribution model of rural logistics joint distribution with three-level transit between counties, towns and villages makes the benefit distribution after the implementation of the joint distribution model more reasonable and fair, which can promote the promotion and application of this model.

4.2 Policy Environment Assessment

The policy environment emphasizes the principle of market-led and government-guided, and closely combines an effective market with an effective government. It takes a market-oriented approach, actively clears policy bottlenecks, guides various market players to innovate service models, and actively participates in the construction of rural express logistics systems. This means that the government will support and encourage logistics companies to adopt blockchain technology through policy guidance to innovate service models and improve service quality.

Guangxi' s Action Plan for Coordinating and Promoting the High-quality Development of Rural Logistics (2022-2025) mentioned that it will rely on Guangxi Supply and Marketing Investment Group Co., Ltd., China Post Guangxi Branch, etc. to build the main channels of rural e-commerce, implement the high-quality development project of rural e-commerce, and accelerate the improvement of the rural e-commerce service system by strengthening the leading enterprises, improving quality, creating brands, unblocking circulation, gathering groups, and expanding marketing. This provides a broad space for the application of blockchain technology in agricultural product traceability, supply chain management, etc., helping to improve the level of agricultural product e-commerce and promote the transfer of industrial products to the countryside and

agricultural products to the city.

The policy environment assessment shows that through policy promotion, logistics companies can be encouraged to adopt blockchain technology, improve logistics efficiency, reduce costs, and enhance transparency, thereby achieving the symbiotic development of the rural logistics system. At the same time, the policy also encourages companies to use blockchain technology to ensure the authenticity of the logistics data collection process, create a three-dimensional supply chain ecological service, further strengthen the credible information flow, and narrow the distance between capital flow and physical flow.

4.3 Evaluation of the Application Effect of Blockchain Technology

Through social participation and satisfaction surveys, the application effect of blockchain technology in rural logistics was evaluated. The evaluation found that the application of blockchain technology reduced unnecessary paperwork and streamlined digital processes through digitalization and decentralization, providing all parties with a safe and reliable way to obtain information, which helped reduce time delays in the logistics process and improve overall efficiency, as shown in Figure 1:

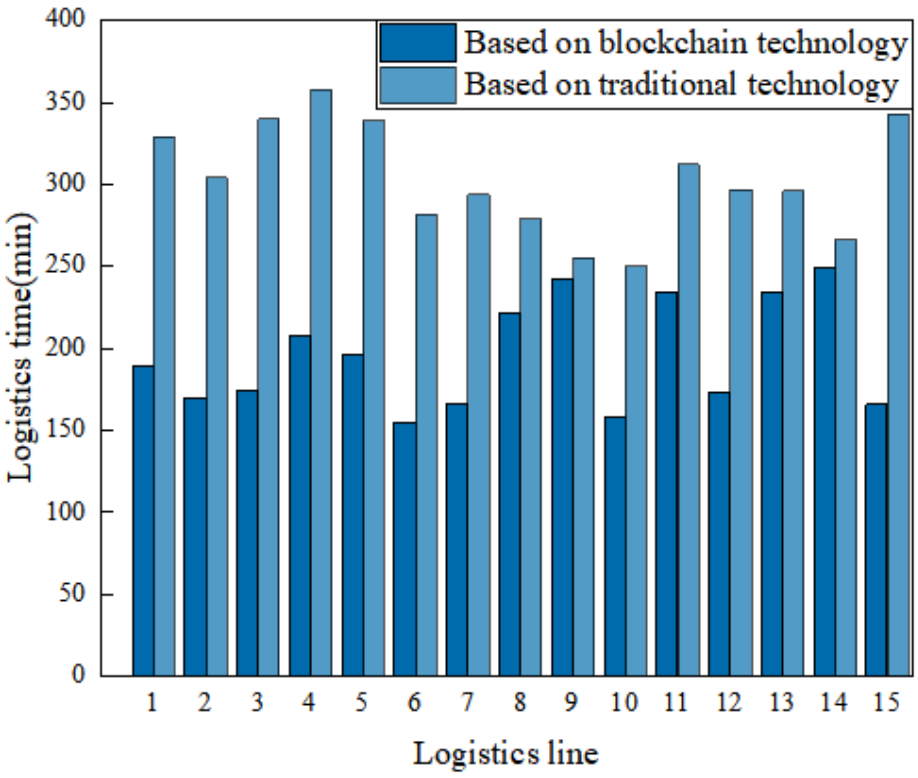

Figure 1: Logistics time

As shown in Figure 1, on line 1, blockchain technology shortens the logistics time from 329 minutes to 189 minutes, a reduction of nearly 140 minutes; on line 3, the logistics time is reduced from 340 minutes to 174 minutes, saving about half time. These significant time reductions not only mean a significant improvement in logistics efficiency, but may also bring multiple positive impacts such as cost reduction and increased customer satisfaction. It is worth noting that although blockchain technology has shown advantages across all lines, the shortening ratio is not entirely

consistent. On Route 6, the logistics time is shortened by about 45%, while on Route 9, the reduction ratio is only 5%. This difference may reflect the specific characteristics and challenges of different logistics lines, and also prompts us to adjust and optimize the implementation of blockchain technology according to specific circumstances in practical applications.

At the same time, blockchain technology can effectively utilize vehicles and reduce waste by managing excess drivers and trucks. It can also prevent the loss of goods and unclear rights and responsibilities during transportation, which helps reduce logistics costs, especially in rural areas. It can effectively manage resources and reduce resource waste, as shown in Figure 2:

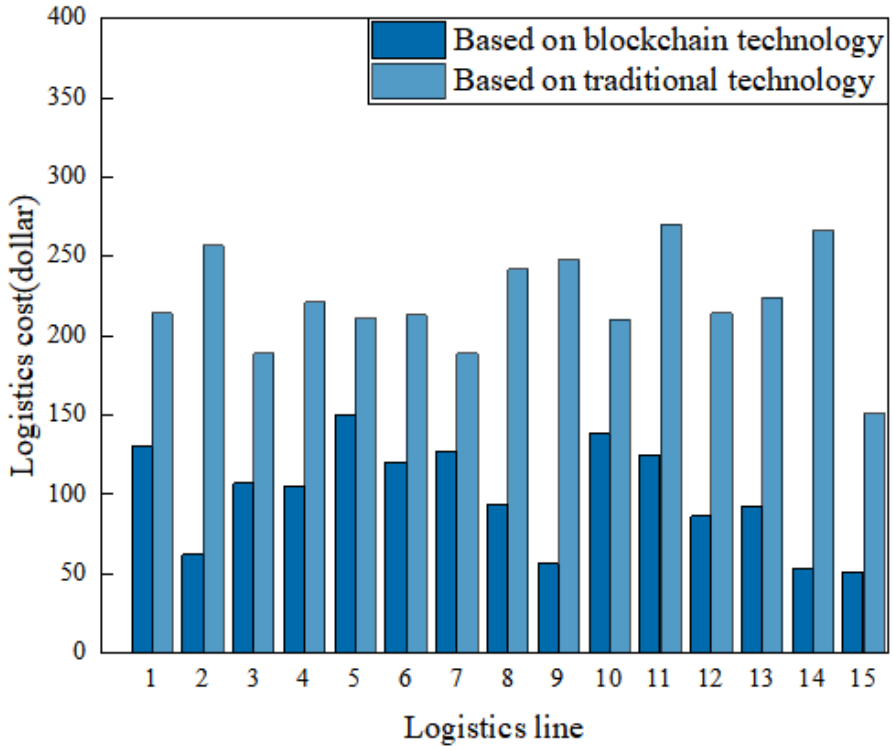

Figure 2: Logistics costs

According to the data analysis in Figure 2, it is found that blockchain technology has shown significant advantages in reducing logistics costs. Through calculation, it is found that under traditional technology, the average logistics cost is approximately $221.3, while after adopting blockchain technology, this value is reduced to approximately $99.7, a decrease of approximately 54%. This data clearly shows that blockchain technology can reduce the operating costs of the logistics industry as a whole, not only saving a lot of expenses for enterprises, but also bringing more cost-effective logistics services to consumers. This cost reduction is due to several core advantages of blockchain technology. First of all, the decentralized nature of the blockchain reduces intermediate links, transaction costs and time costs. In the traditional logistics process, multiple intermediaries are often required to participate. The existence of these intermediaries not only increases the complexity of logistics, but also adds additional costs. Blockchain technology enables all participants to view and verify transactions in real time by providing a transparent, tamper-proof distributed ledger, thereby reducing reliance on intermediaries and simplifying the process.

In addition, the unbreakable and traceable features of blockchain technology provide a guarantee for mode operation, data storage and traceability, which enhances the logistics management of the entire ecosystem and reduces the loss rate of goods, as shown in Figure 3:

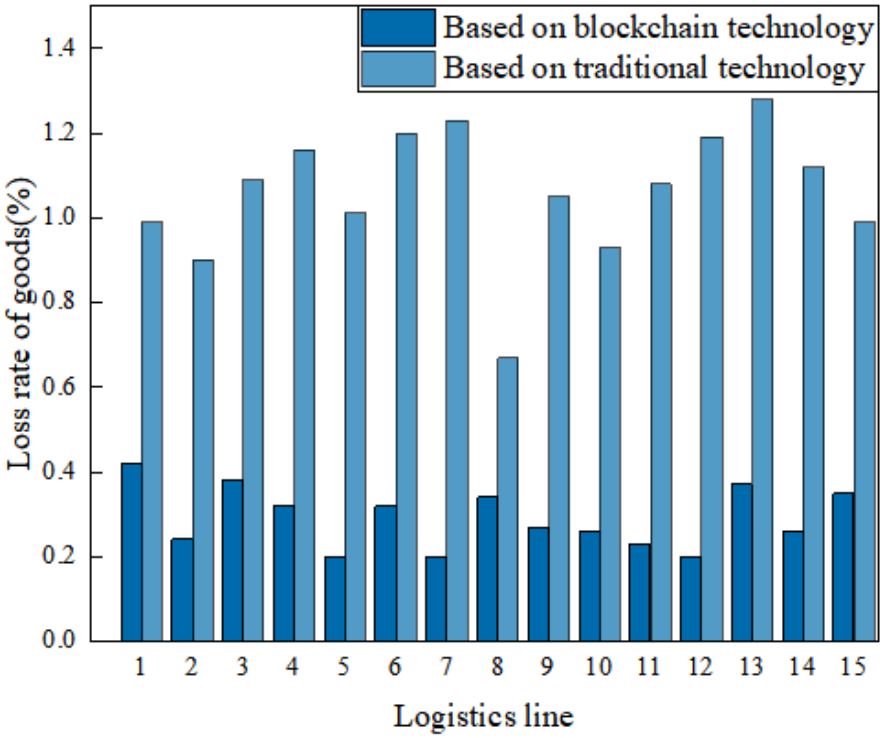

Figure 3: Cargo loss rate

Figure 3 points out that the cargo loss rate data under traditional technology has a maximum value of 1.28% and a minimum value of 0.67%. This shows that in the traditional logistics system, there are differences in cargo loss rates between different lines. The highest loss rate is almost twice as high as the lowest loss rate. This difference is due to various factors such as transportation conditions, personnel quality, and management level. In contrast, under blockchain technology, the maximum value of the cargo loss rate has been reduced to 0.42%, while the minimum value has dropped to 0.2%. The decrease in value indicates that blockchain technology has played a positive role in reducing cargo loss. More importantly, blockchain technology has significantly reduced the difference in cargo loss rates between different lines, improving the stability and reliability of logistics services. Blockchain technology enhances the transparency and traceability of the logistics process by providing features such as tamper-proof data records and smart contracts, thereby reducing the risk of cargo loss. At the same time, blockchain technology can also promote information sharing and collaboration among all parties in the supply chain, improving logistics efficiency and service quality.

5. Conclusion

This paper proposes a symbiotic development system based on blockchain technology to address the problems of low efficiency, high costs, and insufficient informatization in the rural logistics system in Guangxi. Through qualitative research, combined with social network analysis and stakeholder analysis, this study explores the application effects of blockchain technology in improving logistics efficiency, reducing costs, enhancing transparency, and improving supply chain management capabilities. Research results show that the application of blockchain technology significantly improves logistics efficiency and also has advantages in reducing operating costs. In addition, the non-tampering and traceability characteristics of blockchain technology reduce the rate

of cargo loss and improve the transparency and trust of the supply chain. These achievements not only save enterprises money, but also bring more cost-effective logistics services to consumers, thereby solving some key problems in rural logistics in Guangxi. There are also limitations to this study. Firstly, the research is mainly concentrated in Guangxi, and a wider area and more cases are needed to verify the universality of the conclusions; secondly, the application of blockchain technology in rural logistics is still in its early stages and further research is needed to explore its applicability and optimization strategies in different rural logistics scenarios. In the future, we can further explore the in-depth application of blockchain technology in rural logistics, including the application of smart contracts in logistics automation, the role of blockchain in traceability of agricultural products, and how to improve the financial service capabilities of rural logistics through blockchain technology.

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