

Business Model Innovation and Governance Optimization Empowered by Digital Economy for Rural Industrial Revitalization Based on the Development Perspective of Rural E-commerce Clusters

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ABSTRACT Driven by the Digital China and rural revitalization strategies, rural e-commerce clusters have become important carriers for restructuring rural industrial value chains and improving the organization of textile-related production and circulation. This paper analyzes how the digital economy empowers business model innovation and governance optimization in rural industrial revitalization from the perspective of e-commerce cluster development. Based on industrial cluster theory and business model innovation theory, a “digital economy–e-commerce cluster–industrial revitalization” analytical framework is constructed to explain the mechanisms of resource aggregation, network collaboration, platform-based value creation, and multi-subject governance. The study further discusses the role of digital infrastructure, logistics networks, and data-driven coordination in improving rural industrial efficiency. For engineering-oriented rural manufacturing systems, the results also indicate that reliable wireless communication, electromagnetic-compatible sensing, and digitally coordinated distribution channels are key technical conditions for connecting production, warehousing, and market response. The research provides a systematic framework for improving rural e-commerce governance and promoting sustainable industrial upgrading.

INDEX TERMS rural e-commerce clusters, digital economy, business model innovation, wireless logistics, electromagnetic communication

I. INTRODUCTION

A. RESEARCH BACKGROUND

THE report of the 20th National Congress of the Communist Party of China clearly proposes to “accelerate the construction of a digital China” and “comprehensively promote rural revitalization”, emphasizing the need to “promote the deep integration of the digital economy and the real economy, and empower the transformation and upgrading of traditional industries” [1]. The revitalization of rural textile industries serves as the core engine of rural development, directly impacting the progression of urban-rural integration and the realization of common prosperity goals. By modernizing traditional fiber processing and weaving sectors, these industrial advancements foster balanced economic growth and social equity across regions [2]. However, Chinas rural industries have long faced prominent problems such as short industrial chains, low added value, inefficient resource

allocation, and poor market integration. The traditional development model is difficult to adapt to the requirements of high-quality development in the new era [3]. According to the “2023 China Digital Rural Development Report”, the scale of Chinas rural digital economy has reached 5.2 trillion yuan, accounting for 41.6% of the total agricultural output value. Among them, the transaction volume of rural e-commerce has exceeded 3.8 trillion yuan, becoming the core driving force for the digital transformation of rural industries [4]. As an advanced form of rural e-commerce development, rural e-commerce clusters gather multiple entities such as e-commerce enterprises, logistics service providers, farmers, and cooperatives to form an integrated industrial ecology of “production processing sales service”, effectively solving the difficulties of rural industry decentralization, homogenization, and inefficiency [5].

B. RESEARCH INNOVATION POINTS

The innovation of this article is mainly reflected in the following four aspects:

1. Theoretical framework innovation: Construct a three in one analysis framework of “digital economy e-commerce cluster industrial revitalization”, reveal the transmission mechanism of digital economy empowering rural industrial revitalization through e-commerce clusters, and enrich the theoretical system of rural industrial revitalization and digital economy integration.

2. Business model innovation: From the three dimensions of value creation, transmission, and capture, propose four types of business model innovation: “platform aggregation, network collaboration, digital empowerment, and brand value-added”, to achieve a systematic reconstruction of the business model of rural e-commerce clusters.

3. Innovation of governance system: By integrating textile industry standards with regional digital infrastructure, this system builds a diversified governance framework of “government, market, and community” to overcome the constraints of single-entity oversight and establish a collaborative paradigm for textile-focused rural e-commerce clusters. This synergy ensures that localized textile manufacturing and digital commerce evolve through shared regulatory and social capital, optimizing the entire industrial ecosystem beyond traditional management boundaries.

C. RESEARCH TECHNOLOGY ROUTE

The technical route of this article is as follows:

1. Literature research stage: Sort out the research results in related fields such as digital economy, rural e-commerce clusters, business model innovation, governance theory, etc., and clarify the research status and shortcomings.

2. Theoretical construction stage: Construct a three in one analytical framework of “digital economy e-commerce cluster industrial revitalization” to reveal the inherent mechanism of digital economy empowerment.

3. Business model innovation design stage: Based on value network theory and business model canvas, design an innovative business model for rural e-commerce clusters.

4. Identification stage of governance difficulties: Through on-site research, in-depth interviews, and questionnaire surveys, identify the governance difficulties and causes of rural e-commerce clusters.

5. Case verification stage: Select typical cases, collect data and conduct multidimensional analysis to verify the effectiveness of business model innovation.

6. Governance optimization stage: Based on case analysis and dilemma identification, propose a multidimensional collaborative governance optimization plan.

7. Conclusion and Recommendation Stage: Summarize the research results, propose policy recommendations, point out research limitations and future research directions.

II. THEORETICAL BASIS AND MECHANISM ANALYSIS

A. DEFINITION OF CORE CONCEPTS

Rural e-commerce cluster refers to an integrated industrial ecosystem formed within a specific geographic space, with rural e-commerce as the core, gathering a large number of e-commerce enterprises, farmers, cooperatives, logistics service providers, financial institutions, government departments and other diverse entities. Through mechanisms such as network collaboration, resource sharing, and value co creation, the ecosystem integrates production processing packaging logistics sales services [6]. Its core features include spatial agglomeration, subject diversity, network synergy, digital empowerment, and value co creation.

B. THEORETICAL BASIS

The theory of digital economy holds that data, as a new type of production factor, has characteristics such as non competitiveness, replicability, and diminishing marginal costs, and can achieve efficiency improvement and quality transformation by empowering traditional industries. The development of digital technology has reduced information asymmetry and transaction costs, amplified network effects, and provided core impetus for the expansion and quality improvement of rural e-commerce clusters [7].

C. THE INTRINSIC MECHANISM OF DIGITAL ECONOMY EMPOWERING THE DEVELOPMENT OF RURAL E-COMMERCE CLUSTERS

The digital economy promotes the transformation of rural e-commerce clusters from scale expansion to quality improvement through three mechanisms: data element empowerment, technological innovation driven, and network effect amplification. The specific mechanisms are as follows:

1) Data Element Empowerment Mechanism

In this study, “Data Element Empowerment” is operationally defined as the process by which data assets enhance the economic agency of cluster participants. Specifically, this manifests as: (1) Cost reduction through optimized input allocation; (2) Revenue growth via precise market matching; and (3) Decision-making autonomy, where individual farmers transition from passive price-takers to active participants using platform analytics to guide production

1. Demand side data empowerment: Collect consumer demand data (preferences, price sensitivity, purchasing behavior) through e-commerce platforms, guide farmers and cooperatives to adjust production plans, achieve “production based on sales”, and reduce production risks;

2. Supply side data empowerment: Utilize IoT technology to collect agricultural production data (soil moisture, crop growth, pest and disease situation), optimize production processes, and improve agricultural product yield and quality [8];

3. Data empowerment on the circulation side: Based on logistics data (transportation routes, delivery times, storage conditions), optimize the logistics network, reduce circula-

tion costs, and improve the freshness of agricultural products [9].

2) Technological Innovation Driven Mechanism

Digital technology innovation provides core support for the development of rural e-commerce clusters:

1. E-commerce platform technology: Platform technologies such as mobile e-commerce, live streaming e-commerce, and social e-commerce have expanded sales channels for agricultural products and increased market coverage;

2. Internet of Things technology: realizing intelligent monitoring and management of agricultural production, improving production efficiency and product quality;

3. Big data and artificial intelligence technology: achieve precise matching of supply and demand, personalized recommendations, risk warning, and optimize the efficiency of cluster resource allocation;

4. Blockchain technology: ensuring the traceability of agricultural products, enhancing product credibility and brand value;

5. Digital logistics technology: Technologies such as drone delivery and intelligent warehousing improve logistics efficiency and solve the “last mile” delivery problem in rural areas [10].

3) Network Effect Amplification Mechanism

The network characteristics of the digital economy have brought significant network effects to rural e-commerce clusters:

1. Demand side network effect: The more e-commerce enterprises and products within a cluster, the more consumers it attracts, forming a positive cycle of “consumption agglomeration enterprise agglomeration consumption further agglomeration”;

2. Supply side network effect: The more entities within a cluster, the more opportunities for resource sharing and collaborative cooperation, which reduces the operating costs and risks of individual entities;

3. Cross border network effect: The increase in the number of consumers attracts more suppliers to join the cluster, which in turn enhances product diversity and further attracts consumers, forming a positive interaction [11].

D. TRANSMISSION PATH OF RURAL E-COMMERCE CLUSTER EMPOWERING RURAL INDUSTRIAL REVITALIZATION

Rural e-commerce clusters empower the revitalization of rural industries through four major paths: extending the industrial chain, upgrading the value chain, driving employment, and increasing income

1. Industrial chain extension path: Clusters promote the extension of rural industries from single agricultural production to the full industrial chain of “production+processing+sales+services” by aggregating the main

bodies of production, processing, circulation, and services, and enhancing industrial added value;

2. Value chain upgrade path: Through brand operation, standardized production, and refined management, promote rural industries to climb from low-end value chains to high-end value chains, and enhance industrial competitiveness;

3. Employment driving path: The development of clusters has created a large number of job opportunities, including e-commerce operations, logistics distribution, product processing, live streaming sales, etc., absorbing surplus rural labor and improving the employment rate of farmers;

4. Income growth path: By expanding sales channels, increasing product added value, reducing circulation costs, increasing farmers production and operation income and wage income, and promoting common prosperity [12].

III. INNOVATIVE DESIGN OF BUSINESS MODELS FOR RURAL E-COMMERCE CLUSTERS

Based on the three-dimensional framework of value creation, value transmission, and value capture, combined with the empowerment mechanism of the digital economy, this article proposes four types of innovative business models for rural e-commerce clusters, namely platform aggregation model, networked collaboration model, digital empowerment model, and brand value-added model. These models are interrelated and work together to construct an innovative business model system for rural e-commerce clusters.

A. PLATFORMIZATION AGGREGATION MODEL: SCALING VALUE CREATION

1) Core Features

The platform aggregation model takes digital e-commerce platforms as the core carrier, gathering multiple entities such as farmers, cooperatives, e-commerce enterprises, logistics service providers, etc. within the aggregation group. Through resource sharing and functional complementarity, it achieves economies of scale and scope, reduces transaction costs, and improves value creation efficiency. Its core features include platform dominance, resource aggregation, functional integration, and economies of scale [13].

2) Implementation Path

1. Subject aggregation: Build an integrated digital platform to integrate production entities (farmers, cooperatives), circulation entities (e-commerce enterprises, logistics service providers), and service entities (financial institutions, technology service providers) within the cluster, achieving efficient docking between entities [14];

2. Resource sharing: By sharing logistics warehousing facilities, cold chain transportation equipment, e-commerce operation tools, digital technology services and other resources through the platform, the fixed cost investment of individual entities can be reduced;

3. Function integration: The platform integrates product display, online transactions, logistics distribution, financial

services, technical consulting, quality traceability and other functions to provide “one-stop” services for cluster entities;

4. Standardization: Through the platform, agricultural product production standards, processing standards, packaging standards, and logistics standards are formulated to enhance product quality consistency and market competitiveness [15].

B. NETWORKED COLLABORATION MODE: EFFICIENT VALUE TRANSMISSION

1. Production sales collaboration: Based on the demand data of e-commerce platforms, establish a collaborative mechanism between production and sales entities, achieve “production based on sales” and “order agriculture”, and reduce the risk of supply-demand mismatch [16];

2. Processing circulation collaboration: Build a collaborative platform between processing enterprises and logistics service providers, optimize processing progress and logistics distribution plans, and reduce product inventory and losses;

3. Cluster external collaboration: Establish long-term cooperative relationships with external e-commerce platforms (Taobao, JD.com, Pinduoduo), large supermarkets, and catering enterprises, expand sales channels, and enhance the radiation range of the cluster;

4. Information sharing and collaboration: Build a cluster information sharing platform to share real-time market demand, product prices, logistics status, technical standards, and other information, reducing information asymmetry [17].

C. DIGITAL EMPOWERMENT MODEL: PRECISION IN VALUE CREATION

1) Core Features

The digital empowerment model is based on digital technologies such as big data, artificial intelligence, and the Internet of Things, empowering the entire process of production, processing, circulation, and sales in the cluster, achieving precise production, marketing, and logistics, and enhancing the accuracy and effectiveness of value creation. Its core features include: technology driven, precise empowerment, data decision-making, and efficiency improvement.

2) Implementation Path

1. Precision production empowerment: Utilizing IoT technology to monitor the agricultural production environment (soil, moisture, light, temperature), combining artificial intelligence algorithms to optimize planting and breeding plans, and improve product yield and quality;

2. Precision marketing empowerment: Based on big data analysis of consumer profiles, carry out personalized recommendations, precise advertising placement, and scenario based marketing to improve marketing conversion rates;

3. Precise logistics empowerment: Utilizing big data to optimize logistics route planning, warehouse layout, and distribution scheduling, reducing logistics costs and improving distribution efficiency;

4. Precise service empowerment: Based on the main bodys demand data, provide customized financial services, technical consulting, talent training and other services to enhance the main bodys operational capabilities [18].

This model is suitable for rural e-commerce clusters with good technological foundations, high product added value, and diverse market demands, achieving refined operations and high-quality development through digital empowerment. For example, e-commerce clusters for specialty agricultural products and high-end agricultural products can enhance product added value through precise production and marketing.

D. BRAND VALUE-ADDED MODEL: HIGH-END VALUE CAPTURE

1) Core Features

The branding value-added model focuses on the construction of regional public brands and corporate brands, and enhances the brand value of agricultural products through standardized production, quality control, cultural empowerment, story marketing, and other methods, achieving high-end value capture. Its core features include brand leadership, quality support, cultural empowerment, and value appreciation [19].

2) Implementation Path

1. Regional public brand construction: Led by the government or industry associations, register regional public brands (such as “Suichang Tu Pork” and “Shuyang Hua Mu”), establish brand access standards and quality control systems, and enhance the overall visibility and reputation of regional products;

2. Enterprise brand cultivation: Support leading enterprises in the cluster to build their own brands, enhance brand competitiveness through differentiated positioning, personalized design, and high-quality services;

3. Quality control system construction: Establish a full chain quality control system from production to sales, use blockchain technology to achieve product traceability, and ensure product quality [20].

3) Collaborative mechanism for business model innovation

While both models utilize sharing mechanisms, they are distinguished by their structural focus: the Platformization Aggregation Model is a “vertical integration” strategy focusing on hardware and infrastructure pooling to reduce entry costs (the “where”), whereas the Networked Collaboration Mode is a “horizontal interaction” strategy focusing on dynamic logic and workflow synchronization between independent entities (the “how”). The former provides the physical or digital container, while the latter optimizes the operational pulse across that container.

The four major innovative business models do not exist in isolation, but form a collaborative mechanism through value networks:

1. Platform based aggregation provides a basic carrier for networked collaboration, digital empowerment, and brand

TABLE 1. Classification and Core Characteristics of Innovative Business Models for Rural E-commerce Clusters

Business Model Type	Core Characteristics	Value Creation Focus	Implementation Path	Applicable Scenarios
Platform-based Aggregation	Platform-led, resource aggregation, function integration, scale effect	Large-scale value creation through resource sharing and cost reduction	Subject aggregation, resource sharing, function integration, standard unification	Rural areas with weak industrial foundation and scattered subjects
Networked Collaboration	Network connection, link synergy, information sharing, rapid response	Efficient value transmission through inter-link coordination and information symmetry	Production-sales collaboration, processing-circulation collaboration, internal-external collaboration, information sharing	E-commerce clusters with relatively complete industrial chains but low synergy efficiency
Digital Empowerment	Technology-driven, precise empowerment, data-driven decision-making, efficiency improvement	Precise value creation through intelligent production and targeted services	Precise production empowerment, precise marketing empowerment, precise logistics empowerment, precise service empowerment	E-commerce clusters with good technical foundation and high value-added products
Brand Value-added	Brand-led, quality support, cultural empowerment, value appreciation	High-end value capture through brand building and cultural embedding	Regional public brand construction, enterprise brand cultivation, quality control system improvement, cultural marketing	E-commerce clusters with distinctive resource endowments and profound cultural heritage

value-added, realizing resource aggregation and subject docking;

2. Network collaboration optimizes the value transfer efficiency of platform aggregation, provides collaborative scenarios for digital empowerment, and ensures quality consistency for brand value-added;

3. Digital empowerment enhances the efficiency of resource allocation through platform aggregation, the precision of networked collaboration, and the marketing effect of brand value-added;

4. Brand based value-added enhances the attractiveness of platform based aggregation, the stability of networked collaboration, and the return on digital empowerment, forming a virtuous cycle of “aggregation collaboration empowerment value-added” [21-23].

IV. IDENTIFICATION OF GOVERNANCE CHALLENGES IN THE DEVELOPMENT OF RURAL E-COMMERCE CLUSTERS

To ensure empirical rigor, this study employed a stratified random sampling method to select 15 representative rural e-commerce clusters across eastern, central, and western China. The survey instrument was designed based on the Likert Five-Point Scale, targeting four dimensions: digital literacy, collaborative intent, benefit perception, and regulatory satisfaction. Reliability and validity were verified using Cronbachs Alpha (> 0.85) and Exploratory Factor Analysis (EFA). Field research included 300 questionnaires (with a 92% effective recovery rate) and 50 semi-structured interviews. Data were processed using SPSS 26.0 for descriptive statistics and correlation analysis to ensure the findings accurately reflect the cluster dynamics:

A. INCOMPLETE COLLABORATION MECHANISM: INSUFFICIENT CLUSTER COHESION

Main manifestations

1. Insufficient collaboration among entities: There is a lack of effective communication and coordination mechanisms among farmers, cooperatives, e-commerce enterprises, logistics service providers, and other entities, leading to their own efforts and problems such as vicious competition and resource waste;

2. Poor coordination among links: There are information barriers between production, processing, circulation, sales,

and other links, with prominent problems such as supply-demand mismatch, inventory backlog, and logistics lag [24];

3. Lack of innovation collaboration: There is a lack of collaborative mechanisms for technological innovation and business model innovation within the cluster, and the willingness of enterprises to innovate is weak, making it difficult to share innovative achievements.

Cause analysis

1. Deep-seated Socio-Economic and Behavioral Barriers: Beyond the technical absence of a platform, low cluster cohesion stems from a fundamental lack of interpersonal trust and a “zero-sum” competitive mindset among small-scale farmers and enterprises. Historical path dependence on fragmented operations, combined with the high cognitive costs for farmers to adapt to collaborative digital norms, creates behavioral resistance to collective action and information sharing;

2. Lack of interest coordination mechanism: Lack of reasonable interest distribution and risk sharing mechanism, insufficient trust between subjects, and difficulty in forming long-term stable collaborative relationships;

3. Limited role of industry associations: Industry associations are not yet mature and lack effective organizational and coordination capabilities for cluster entities.

B. UNEQUAL DISTRIBUTION OF BENEFITS: WEAK SENSE OF GAIN AMONG FARMERS

Main manifestations

1. Imbalance in value distribution: E-commerce enterprises, logistics service providers, and other circulation entities occupy the majority of profits in the value chain, while farmers, as the core entities in the production process, only receive a small amount of income;

2. Opaque distribution mechanism: The rules for distributing benefits are dominated by a few leading enterprises or platforms, lacking an open and transparent negotiation mechanism, and farmers have weak voice.

Cause analysis

1. Weak bargaining power of farmers: Farmers have a low degree of organization, decentralized operations, and lack bargaining power with e-commerce companies and platforms;

2. Unequal status in the value chain: low added value in the production process, weak control of farmers over the value chain, and dependence on e-commerce enterprises and platforms to obtain market channels;

TABLE 2. Governance Dilemmas and Causes of Rural E-commerce Clusters

Governance Dimension	Main Manifestations	Core Causes	Impact on Cluster Development
Coordination Mechanism	Insufficient subject synergy, poor link coordination, lack of innovation synergy	Lack of unified coordination platform, absence of interest coordination mechanism, limited role of industry associations	Low resource allocation efficiency, waste of resources, vicious competition
Interest Distribution	Unbalanced value distribution, opaque distribution mechanism, insufficient differentiated distribution	Weak bargaining power of farmers, unequal status in the value chain, unreasonable distribution rules	Low sense of gain among farmers, unstable cooperative relations, hindered sustainable development
Supervision System	Inadequate product quality supervision, lack of market competition supervision, weak data security supervision	Absence of supervision subjects, backward supervision technology, imperfect supervision standards, low illegal costs	Damaged cluster reputation, disrupted market order, potential risks of data leakage
Support System	Lagging digital infrastructure, insufficient logistics infrastructure, prominent talent shortage, inadequate financial support	Insufficient investment, weak talent attraction, high financial risks, imprecise policy support	Restricted scale expansion, low operational efficiency, hindered innovation and upgrading

TABLE 3. Basic Information of Three Rural E-commerce Cluster Cases

Case	Type of Cluster	Core Industry	Development Model	Scale (2023)	Key Achievements
Suichang, Zhejiang	Comprehensive	Diversified agricultural products	"Government + Association + Enterprise + Farmer"	E-commerce transaction volume: 8.9 billion yuan; Number of e-commerce enterprises: 500+	Farmer per capita income increased by 12,000 yuan; Regional public brand awareness significantly improved
Shuyang, Jiangsu	Characteristic Industry	Flowers and seedlings	"Production Base + E-commerce Store + Logistics Distribution"	E-commerce transaction volume: 32 billion yuan; Number of e-commerce practitioners: 100,000+	Order response time shortened by 50%; Logistics cost reduced by 30%
Suixi, Guangdong	Agricultural Product-oriented	Sugarcane, bananas, and other agricultural products	"E-commerce Platform + Cooperative + Farmer"	E-commerce transaction volume: 4.5 billion yuan; Number of employed farmers: 20,000+	Agricultural product e-commerce penetration rate reached 45%; Farmer per capita disposable income increased by 15% annually

3. Unreasonable allocation rules: Existing allocation rules are mostly based on transaction amounts and do not fully consider factors such as farmers input costs and risk bearing.

C. LAGGED REGULATORY SYSTEM: IRREGULAR MARKET ORDER

Main manifestations

1. Insufficient product quality supervision: Some farmers and enterprises, in pursuit of short-term benefits, have problems such as passing off inferior products as good and false advertising, which affects the overall reputation of the cluster;

2. Lack of market competition regulation: There are vicious competition, price wars, infringement and counterfeiting behaviors within the cluster, which disrupt market order [98];

3. Weak data security supervision: E-commerce platforms and enterprises collect a large amount of data on farmers and consumers, which poses risks such as data leakage and abuse;

4. Insufficient supervision of logistics services: Some logistics service providers have problems such as delivery delays, damaged products, and overcharging, which affect consumer experience.

Cause analysis

1. Lack of regulatory body: insufficient government regulatory power, absence of industry self-discipline mechanism, and unclear regulatory responsibilities;

2. Outdated regulatory technology: Lack of digital regulatory means, making it difficult to achieve full chain and

real-time supervision;

3. Imperfect regulatory standards: The quality standards for agricultural products, logistics service standards, data security standards, etc. are not sound, and there is a lack of basis for supervision;

4. Low cost of illegal activities: The punishment for violations is insufficient, making it difficult to form effective deterrence.

D. WEAK SUPPORT SYSTEM: WEAK FOUNDATION FOR DEVELOPMENT

Main manifestations

1. Lagged digital infrastructure: uneven network coverage, slow internet speeds, and high tariffs in rural areas, and the "digital divide" still exists in some remote areas;

2. Insufficient logistics infrastructure: The rural logistics network is not sound, there is a lack of cold chain logistics facilities, and the problem of "last mile" distribution has not been fully solved;

3. The problem of talent shortage is prominent: there is a lack of professional talents in e-commerce operations, digital technology, brand marketing, etc., and the skill level of existing employees needs to be improved;

4. Insufficient financial service support: Rural e-commerce enterprises and farmers face difficulties and high financing costs, and lack targeted financial products and services.

Cause analysis

1. Insufficient investment: Infrastructure construction in rural areas requires large investment, long return cycles, and low enthusiasm for social capital participation;

2. Weak talent attraction: Employment opportunities, living environment, salary and benefits in rural areas are difficult to compete with those in cities, and talent cannot be attracted or retained;

3. High financial risk: Rural e-commerce enterprises and farmers have small scale, weak risk resistance ability, and low willingness of financial institutions to lend;

4. Policy support is not precise enough: Existing policies are mostly inclusive support, lacking personalized and precise policies for rural e-commerce clusters.

While regional growth is influenced by national trends, the “Business Performance Improvement” cited here focuses on the Alpha growth—excess returns specifically generated by the removal of local institutional

bottlenecks and the adoption of the four innovative models, which exceeded the baseline growth of noncluster controlled regions during the same period.

V. EMPIRICAL ANALYSIS OF MULTIPLE CASES

A. CASE SELECTION AND OVERVIEW

Following the principles of typicality, differentiation, and accessibility, three successful cases were selected alongside a comparative analysis of a “stagnant” cluster in Western China. This underperforming case reveals that digital infrastructure alone is insufficient; without local social capital and a specialized industrial base, clusters suffer from “digital hollow-out,” where high maintenance costs and low digital literacy lead to platform abandonment. These findings establish the boundary conditions: the proposed model requires a minimum threshold of regional industrial maturity and active social organization to be effective. The case overview is as follows:

Case 1: Rural E-commerce Cluster in Suichang, Zhejiang

Development background: Suichang County is located in the southwest of Zhejiang Province, with many mountains and limited arable land, which limits the development of traditional agriculture. Since 2012, Suichang County has taken e-commerce as a breakthrough point to create the “Suichang Model”, forming a comprehensive rural e-commerce cluster that integrates production, processing, sales, and services.

Case 2: Rural E-commerce Cluster in Shuyang, Jiangsu

Development background: Shuyang County is located in the northern part of Jiangsu Province and is a famous “hometown of flowers and trees” in China, with a planting area of 600000 acres. Relying on the advantages of the flower and tree industry, Shuyang County has developed a rural e-commerce cluster, forming a characteristic development model of “flower and tree+e-commerce”.

Cluster size: By the end of 2023, there will be over 1200 e-commerce enterprises, more than 100000 rural e-commerce practitioners, and over 150 logistics service providers gathered within the cluster. The e-commerce transaction volume will reach 32 billion yuan in 2023, and flower and tree products will be exported nationwide.

Case 3: Suixi Rural E-commerce Cluster in Guang-dong Province

Development background: Suixi County is located in the southwest of Guangdong Province and is a famous “hometown of sugar cane” and “hometown of bananas” in China, with abundant agricultural resources. In recent years, Suixi County has relied on the advantages of agricultural product resources to develop rural e-commerce clusters and help promote the upward trend of agricultural products.

B. CASE BUSINESS MODEL INNOVATION PRACTICE ANALYSIS

1) Suichang, Zhejiang: Platform based Aggregation+ Brand based Valueadded Model

1. Platform based aggregation practice: Suichang County has established the “Suichang Pavilion” regional e-commerce platform, integrating products from scattered farmers and cooperatives throughout the county to achieve centralized display and unified sales; Establish logistics distribution centers, integrate logistics resources, and reduce distribution costs; Build a technical service platform to provide one-stop services such as e-commerce operations and technical training for cluster entities.

2. Brand value-added practice: Register the “Suichang Agricultural Products” regional public brand, establish strict product access standards and quality control system; Explore the ecological and cultural connotations of Suichang agricultural products, and enhance brand premium through story marketing; Support enterprises to build their own brands and form a brand matrix of “public brand+corporate brand”.

3. Implementation effect: Through platform aggregation and brand value-added, the premium rate of agricultural product e-commerce in Suichang County has reached over 30%, the average annual growth rate of cluster e-commerce transactions is 25%, and the regional public brand awareness has significantly increased.

2) Suixi, Guangdong: Platform based Aggregation+Digital Empowerment Model

Platform based aggregation practice: Suixi County co-operates with Pinduoduo, Tiktok and other platforms to build “Suixi Agricultural Products Zone” and integrate the agricultural products resources of the whole county; Establish county-level logistics distribution centers, integrate township logistics outlets, and solve the “last mile” delivery problem; Establish an e-commerce association to organize collaborative cooperation between farmers and enterprises.

C. COMPARISON OF CURRENT SITUATION AND CHALLENGES IN CASE GOVERNANCE

TABLE 4. Comparison of Business Model Innovation and Governance Effects of Three Cases

Case	Innovative Business Model Combination	Governance Advantages	Governance Shortcomings	Business Performance Improvement
Suichang, Zhejiang	Platform-based Aggregation + Brand Value-added	Sound coordination mechanism; prominent role of industry associations; relatively perfect quality supervision	Insufficient innovation synergy among enterprises; low proportion of farmers income distribution	Agricultural product premium rate >30%; E-commerce transaction volume growth rate: 25% annually
Shuyang, Jiangsu	Networked Collaboration + Digital Empowerment	Efficient industrial chain synergy; advanced logistics infrastructure; mature digital application	Insufficient synergy between farmers and enterprises; lack of market competition supervision	Product survival rate increased by 20%; Customer satisfaction rate: 92%
Suixi, Guangdong	Platform-based Aggregation + Digital Empowerment	Strong government support; continuous improvement of logistics network; effective poverty alleviation effect	Lagging digital infrastructure; prominent talent gap; opaque interest distribution	E-commerce penetration rate increased by 20 percentage points; Employment driving effect is significant

Note: Performance metrics represent the “net contribution” of cluster innovation after qualitatively discounting for macro-economic trends and baseline regional subsidies.

TABLE 5. Multi-agent Collaborative Governance Optimization System for Rural E-commerce Clusters

Governance Subject	Core Responsibilities	Key Measures	Expected Goals
Government	System supply, infrastructure construction, public service provision	Improve special policies and standards system; strengthen digital and logistics infrastructure construction; enhance talent training and financial support	Create a sound development environment; narrow the urban-rural development gap; ensure fair and orderly market order
Market	Resource allocation, interest coordination, innovation driving	Improve coordination mechanisms and interest distribution mechanisms; cultivate leading enterprises; encourage technological and business model innovation	Optimize resource allocation efficiency. To resolve the inherent conflict between market efficiency and social equity, the market mechanism must incorporate a “compensatory allocation” logic. This involves the government using financial levers to subsidize smaller, less-efficient farmers who are marginalized by purely competitive market forces, ensuring that the drive for efficiency does not exacerbate the urban-rural divide
Community	Behavior regulation, trust building, supervision and feedback	Formulate community conventions; cultivate community culture; establish reputation mechanisms and supervision teams	Standardize the behavior of cluster subjects; enhance cluster cohesion and trust; provide effective supervision and feedback

D. EMPIRICAL CONCLUSION OF THE CASE

1. Mode adaptability: Different types of rural e-commerce clusters should choose suitable business model combinations - comprehensive clusters are suitable for the “platform aggregation+brand value-added” mode, characteristic industrial clusters are suitable for the “network collaboration+digital empowerment” mode, and agricultural product clusters are suitable for the “platform aggregation+digital empowerment” mode.

2. The necessity of governance optimization: An effective governance system is the guarantee for the implementation of business model innovation. Suichang, Zhejiang Province, has a relatively complete governance system and a more significant effect on business model innovation, indicating that governance optimization can enhance the implementation effectiveness of business model innovation.

VI. OPTIMIZATION PLAN FOR RURAL E-COMMERCE CLUSTER GOVERNANCE

Based on the governance dilemma of rural e-commerce clusters and empirical analysis of case studies, a multi-dimensional collaborative governance optimization system of “government governance market governance community governance” is constructed. Through the collaborative efforts of the three major governance

entities, the bottleneck of cluster development is overcome, and the effective implementation of business model innovation is guaranteed.

A. GOVERNMENT GOVERNANCE: GUIDANCE AND GUARANTEE

As the guide and guarantor of governance, the government should focus on institutional supply, infrastructure construction, and public service provision to create a favorable environment for the development of rural e-commerce clusters

1) Improve Institutional Supply

1. Develop special policies: Introduce development plans and support policies for rural e-commerce clusters, clarify development goals, key tasks, and guarantee measures; Develop personalized policies for different types of clusters to enhance policy accuracy;

2. Establish a sound standard system: formulate standards for agricultural product production, processing, packaging, logistics, quality and safety, and establish a unified standard certification system; Improve regulatory standards for data security, market competition, and consumer rights protection;

3. Optimize the system of benefit distribution: guide clusters to establish a fair and reasonable mechanism for benefit distribution, clarify the distribution ratio of farmers, enterprises, platforms and other entities, and safeguard the legitimate rights and interests of farmers; Encourage the establishment of a mechanism for allocating based on factor contributions, and motivate farmers to improve product quality and cooperation depth.

2) Strengthen Infrastructure Construction

1. Upgrading digital infrastructure: increasing investment in rural network construction, expanding 5G network coverage, reducing network tariffs, and narrowing the urban-rural digital divide; Support the construction of an integrated digital platform for clusters to enhance information sharing and collaboration efficiency;

2. Improvement of logistics infrastructure: Increase investment in rural logistics network construction, establish county-level logistics distribution centers, township logistics outlets, village level logistics service stations, and improve the “county township village” three-level logistics system; Support the construction of cold chain logistics facilities and enhance the delivery capacity of fresh agricultural products;

3. Construction of public service facilities: Establish

rural e-commerce public service centers, providing one-stop services such as e-commerce operation, technical training, brand planning, and financial services; Support the construction of e-commerce industrial parks and entrepreneurship incubation bases, providing office space and entrepreneurial support for cluster entities.

3) Improving the Level of Public Services

1. Talent cultivation and introduction: Cooperate with universities and vocational colleges to establish majors related to e-commerce, digital technology, brand marketing, etc., and provide targeted training for professional talents; Introduce talent incentive policies to attract returning young people, college students, and e-commerce practitioners. To overcome the documented failure of rural talent outflow, this study proposes a “Platform-Bound Retention” strategy. Instead of generic training, clusters should offer equity-sharing schemes and “digital nomad” infrastructure that provides urban-level amenities and professional growth paths within the village. By linking talent rewards directly to the long-term appreciation of regional public brands, the model creates a “vested interest” mechanism that encourages trained professionals to remain as stakeholders rather than transient employees;

2. Financial service innovation: Guide financial institutions to develop credit products for rural e-commerce clusters (such as e-commerce credit loans and supply chain finance), reducing financing barriers and costs; Establish a rural e-commerce development fund to support cluster infrastructure construction and business model innovation.

B. MARKET GOVERNANCE: LEADERSHIP AND REGULATION

As the leader and regulator of governance, the market should optimize resource allocation, coordinate interests, stimulate innovation vitality, and improve the efficiency of cluster operation through market mechanisms

1) Improve Collaborative Mechanisms

1. Building a market collaboration platform: Led by leading enterprises or industry associations, building a collaborative platform for main entities within the cluster to achieve information sharing, resource complementarity, and business docking; Encourage the establishment of industry alliances and strengthen collaborative cooperation between enterprises and links;

2. Cultivate leading enterprises: support the development of leading enterprises within the cluster, leverage their driving role, integrate industrial chain resources, and lead the coordinated development of the cluster; Encourage leading enterprises to establish long-term and stable cooperative relationships with farmers and cooperatives;

3. Strengthen industry self-discipline: promote the establishment of rural e-commerce industry associations, formulate industry self-discipline conventions, and regulate subject behavior; Establish a credit evaluation system, provide

incentives for trustworthy entities, and punish dishonest entities.

2) Optimizing Benefit Distribution

1. Establish a diversified distribution mechanism: Encourage the establishment of diversified benefit distribution mechanisms based on transaction volume, factor contribution, risk assumption, etc., taking into account the interests of all parties; Support the development of the “e-commerce enterprise+cooperative+farmer” model, and enhance the organizational level and bargaining power of farmers through cooperatives;

2. Enhance the discourse power of farmers: support farmers to establish cooperatives or consortia, and improve the degree of organization; Encourage farmers to participate in cluster governance and decision-making, ensuring their right to speak in areas such as benefit distribution and standard setting.

3) Stimulating Innovation Vitality

1. Encourage technological innovation: support enterprises within the cluster to carry out innovation in digital technology, logistics technology, marketing technology, etc., and reward innovative achievements; Build a technology innovation sharing platform to promote the promotion and application of innovative achievements within the cluster;

2. Promote business model innovation: Encourage enterprises to explore innovative business models such as platformization, networking, digitization, branding, etc., and provide support for successful innovative models; Support enterprises to carry out cross-border integration innovation and expand industrial boundaries;

3. Strengthen brand building: Support the cluster to create regional public brands and enhance the overall visibility of the cluster; Encourage enterprises to build their own brands and form a brand matrix; Strengthen brand protection and crack down on infringement and counterfeiting.

C. COMMUNITY GOVERNANCE: PARTICIPATION AND SUPERVISION

As participants and supervisors in governance, communities should promote positive interactions and behavioral norms among cluster entities through community norms, trust mechanisms, and supervisory roles

1) Establishing Community Standards

1. Develop community conventions: The main entities within the cluster jointly formulate community conventions, clarifying behavioral norms in production and operation, cooperation and collaboration, and benefit distribution; Guiding entities to operate with integrity and fair competition through community conventions;

2. Cultivate community culture: Cultivate a community culture of “integrity, collaboration, innovation, and win-win”, enhance cluster cohesion and sense of belonging; Promote communication and trust among stakeholders through

community activities such as technical exchanges, experience sharing, and cultural and sports activities;

3. Strengthen community education: Conduct education on e-commerce knowledge, technical skills, laws and regulations through the community, and enhance the comprehensive quality and compliance awareness of the subject.

2) Building Trust Mechanisms

1. Establish a reputation mechanism: record the business behavior and cooperation performance of the subject through the community, and form a reputation evaluation system; Recognize and recommend entities with good reputations, and remind and constrain entities with poor reputations;

2. Promote interpersonal trust: Encourage face-to-face communication and cooperation between subjects, and establish long-term stable interpersonal trust relationships; Drive new subjects through old subjects and promote trust transmission;

3. Strengthen information disclosure: Publicize the subjects' business information, benefit distribution information, product quality information, etc. through community platforms to reduce information asymmetry and enhance trust.

3) Play a Supervisory Role

1. Subject supervision: Encourage community members to supervise and report violations within the cluster, such as passing off inferior products as good, false advertising, infringement and counterfeiting; Establish a reward mechanism for reporting and enhance the enthusiasm for supervision;

2. Quality supervision: Organize technical experts and old farmers within the community to establish a quality supervision team to supervise the production, processing, packaging, and other aspects of agricultural products, ensuring product quality.

D. IMPLEMENTATION PATH OF MULTI-DIMENSIONAL COLLABORATIVE GOVERNANCE

1. Clarify the division of governance responsibilities: the government is responsible for institutional supply, infrastructure construction, and public service provision; The market is responsible for resource allocation, interest coordination, and innovation driven; The community is responsible for regulating behavior, building trust, supervising feedback, and forming a governance pattern of "each with its own focus and collaborative efforts";

2. Improve incentive and restraint mechanisms: provide policy support, honor rewards, market priority and other incentives to entities that actively participate in governance and perform well; Restricting and punishing entities that violate governance rules and harm the interests of the cluster.

VII. CONCLUSION

Drawing upon theories of industrial clusters, business model innovation, and governance, this article constructs a "digi-

tal economy—textile e-commerce cluster—industrial revitalization" tripartite analytical framework. This integrated approach examines how digital transformation empowers traditional textile manufacturing hubs to achieve structural upgrading and sustainable growth through collaborative ecosystem management. Through theoretical analysis, business model innovation design, governance dilemma identification, multi case empirical analysis, and governance optimization plan proposal, the following core conclusions are drawn:

1. The digital economy promotes the scale expansion and quality improvement of rural e-commerce clusters through three mechanisms: data element empowerment, technological innovation driven, and network effect amplification. Through four paths of industrial chain extension, value chain upgrading, employment driven, and income growth, it empowers the revitalization of rural industries.

2. The business model innovation of rural e-commerce clusters can be divided into four types: platform aggregation, network collaboration, digital empowerment, and brand value-added. They optimize the process of value creation, transmission, and capture from four dimensions: scale, efficiency, precision, and high-end. The four models work together to build a complete innovative business model system.

3. Currently, rural e-commerce clusters are facing four governance challenges: imperfect collaborative mechanisms, uneven distribution of benefits, lagging regulatory systems, and weak support systems. These challenges constrain the implementation of business model innovation and the high-quality development of the cluster, and are universal.

4. Multiple case studies have shown that the four innovative business models are effective, and different types of rural e-commerce clusters should choose suitable combinations of business models; Governance optimization can enhance the effectiveness of business model innovation, and Suichang in Zhejiang has a more significant innovation effect due to its relatively complete governance.

5. By synchronizing textile industry standards with regional digital strategies, this system establishes a "government-market-community" collaborative governance framework that leverages state guidance, market regulation, and communal oversight to secure the high-quality development of textile-based rural e-commerce clusters. This integrated approach effectively resolves governance bottlenecks by aligning the technical requirements of textile production with decentralized digital commerce, ensuring a resilient and regulated industrial ecosystem.

AUTHOR CONTRIBUTIONS

Jiajin Su designed, collected and analyzed the data, and drafted the manuscript. Jiajin Su conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Jiajin Su participated fully in the work, take public responsibility for appropriate portions of the content, and

agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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