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Impact of Digital Inclusive Finance on Rural E-Commerce Development in Baoding: An Empirical Study Based on Village-Level Service Station Data

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Abstract: Utilizing data from 5,481 village-level service stations (VS) in Baoding, China, this study empirically investigates the impact of digital inclusive finance (DIF) and VS infrastructure on rural e-commerce (RE) development. Results demonstrate that DIF significantly promotes RE by reducing transaction and financing costs ($\beta = 0.783$, $P < 0.01$). VS as physical infrastructure significantly drives RE growth ($\beta = 0.654$, $P < 0.01$). Crucially, DIF and VS exhibit synergistic effects (interaction $\beta = 0.421$, $P < 0.01$), producing a "1+1>2" enhancement. Regional economic development, population density, and education levels positively influence RE. Current challenges include financial misallocation, infrastructure deficits, and skill gaps. We propose a "One Core, Three Wings" framework—Core: Develop tailored financial products for specialty industries (luggage, textiles, mushrooms); Wings: (1) Upgrade digital infrastructure, (2) Optimize policy synergy, (3) Enhance inclusive capacity through elderly-friendly technologies and training. Implementation strategies include establishing risk-sharing mechanisms, expanding VS functionality, and creating DIF-RE-VS alliances to foster sustainable rural revitalization.

Keywords: Digital inclusive finance; Rural e-commerce development; Village-level service station; Synergistic effect; Rural revitalization

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1. Introduction

Amidst the vigorous development of the digital economy and the deepening implementation of the rural revitalization strategy, rural e-commerce, as a crucial engine for activating rural industries and increasing farmers' income, is reshaping the production and operational landscape of agriculture and rural areas at an unprecedented pace. As a key node city in the Coordinated Development of the Beijing-Tianjin-Hebei Region and a major

agricultural city in Hebei Province, Baoding possesses abundant, distinctive agricultural product resources and a foundation in traditional handicrafts, endowing it with unique potential for developing rural e-commerce. However, while Baoding's rural e-commerce is experiencing rapid growth, it also commonly faces financial constraints such as financing difficulties, inconvenient payment settlements, and high operational risks, which hinder its scaled and sustainable development.

Through systematic theoretical analysis and empirical examination, this research aims to conduct an in-depth analysis of the interaction mechanisms, impacts, and regional heterogeneity between digital inclusive finance and rural e-commerce development. The study will not only contribute to enriching the theoretical framework on how digital inclusive finance supports the development of regionally distinctive rural e-commerce, filling a gap in localized research for Baoding, but also provide practical decision-making references for Baoding and similar regions. These include optimizing digital inclusive finance policies for government departments, innovating product and service offerings for financial institutions, and enhancing financial capabilities for e-commerce entities. Consequently, this research seeks to promote the higher-quality and more sustainable development of rural e-commerce in Baoding and contribute to the comprehensive revitalization of rural areas.

2. Literature review and theoretical framework

Current research indicates that digital inclusive finance exerts a significantly positive effect on the development of rural e-commerce [1]. It effectively expands the reach of financial services and reduces service costs, thereby driving rural industrial upgrading and increasing rural residents' income [2]. The development of rural e-commerce serves as an effective means for boosting farmers' income, and digital inclusive finance facilitates this development by providing crucial financial support [3,4].

First, digital inclusive finance lowers transaction costs and reduces barriers to financial services, offering rural e-commerce operators more accessible financing channels [5]. Traditional financial institutions have undertaken measures to support e-commerce development, such as deploying more financial terminals, establishing bank-led e-commerce service platforms, and providing financial credit products. However, their effectiveness is constrained by challenges specific to rural e-commerce, including a lack of collateral, limited financing avenues, high financing costs, and difficulties in credit assessment [6]. In contrast, leveraging technologies like big data, artificial intelligence, and blockchain, digital inclusive finance reduces service costs, extends reach to more rural clients, enhances service quality and efficiency, and mitigates issues of information asymmetry and credit risk.

Second, by fostering the growth of the digital economy, digital inclusive finance creates a broader developmental space for rural e-commerce. Studies demonstrate that the digital economy primarily facilitates rural e-commerce development through two mechanisms: the human capital effect and the technological innovation effect. As a vital component of the digital economy, digital inclusive finance promotes rural e-commerce by enhancing the digital literacy and innovative capabilities of rural residents. Furthermore, it stimulates rural consumption growth, thereby generating greater market demand for rural e-commerce. Research confirms that digital inclusive finance significantly boosts rural consumption, with notable spatial spillover effects. Through digital payments, credit, insurance, and other avenues, it strengthens the consumption capacity of rural residents. This enhanced capacity not only facilitates agricultural product distribution but also promotes the procurement of industrial goods in rural areas, forming a virtuous cycle of bidirectional urban-rural flow.

Existing studies generally corroborate the positive role of digital inclusive finance in advancing rural

e-commerce, primarily through mechanisms such as alleviating financing constraints, reducing transaction costs, enhancing operational efficiency, and empowering market entities [7]. However, much of this research concentrates on developed eastern coastal regions or adopts a macro, national-level perspective. There remains a notable scarcity of targeted, in-depth empirical studies on regional cases like Baoding, which possesses unique characteristics: its strategic location within the Beijing-Tianjin-Hebei region, coupled with the presence of underdeveloped counties in the Taihang Mountains, and its distinctive industrial structure and e-commerce development models. Key questions demanding further investigation include: What unique opportunities and challenges do rural e-commerce entities in Baoding encounter when utilizing digital inclusive finance? Are there significant variations in the impact of different types of digital financial tools on e-commerce development across Baoding's diverse counties and industries? How can digital inclusive financial service models be optimized according to Baoding's regional characteristics to maximize their supportive efficacy?

3. Methodology and empirical analysis

3.1. Research hypotheses

H_1: DIF development positively correlates with RE growth.

H_2: DIF directly promotes RE development.

H_3: VS construction accelerates RE expansion.

H_4: DIF-VS interaction produces synergistic effects.

3.2. Data and variables

(1) Data sources:

(a) Baoding Municipal Bureau of Commerce: Provided data on rural e-commerce development, including online retail sales value and the value of agricultural product distribution.

(b) Baoding Municipal Bureau of Agriculture and Rural Affairs: Provided data on agricultural production and agricultural product sales.

(c) Baoding Municipal Financial Regulatory Bureau: Provided data on rural financial development, including the number of financial institutions, outstanding loan balances, etc.

(d) Various Statistical Yearbooks: Provided supplementary statistical data.

(2) Variable definitions:

(a) Dependent variable: Rural E-commerce Development Level (RE): Measured by the online retail sales value (in 10,000 yuan) at the village level.

(b) Independent variables:

(i) Digital inclusive finance development level (DPF): Represented by a composite index incorporating indicators such as the number of digital financial users and the volume of digital financial transactions.

(ii) Village-level service station construction level (VS): Represented by a composite index incorporating indicators such as the number of service stations, the scope of services offered, and service effectiveness.

(c) Control variables: Included economic development level (GDP), population density (PD), education level (ED), among others.

(3) Estimation method: Given the potential existence of heteroskedasticity and autocorrelation in the data, this study employs Weighted Least Squares (WLS) for estimation. Robustness tests were conducted to validate the results.

3.3. Econometric model

$$RE_i = \beta_0 + \beta_1 DPF_i + \beta_2 VS_i + \beta_3 DPF_i \times VS_i + \beta_4 GDP_i + \beta_5 PD_i + \beta_6 ED_i + \varepsilon_i$$

(1) i denotes the i-th village-level service station.

(2) β_0 is the constant term (intercept).

(3) β_1 represents the coefficient capturing the impact of the Digital Inclusive Finance Development Level (DPF) on the Rural E-commerce Development Level (RE).

(4) β_2 represents the coefficient capturing the impact of the Village-level Service Station Construction Level (VS) on the Rural E-commerce Development Level (RE).

(5) β_3 represents the coefficient of the interaction term between Digital Inclusive Finance (DPF) and Village-level Service Station Construction (VS), capturing their combined effect on Rural E-commerce Development (RE).

(6) β_4 to β_6 are the coefficients of the control variables.

(7) ε_i is the error term.

3.4. Empirical results

3.4.1. Descriptive statistical analysis

Based on **Table 1**, the mean value of the Rural E-commerce Development Level (RE) is 52.3, with a standard deviation of 15.7. This indicates substantial variation in rural e-commerce development levels across different village-level service stations. Similarly, the mean value of the Digital Inclusive Finance Development Level (DPF) is 3.6, with a standard deviation of 1.2, also suggesting considerable variation in digital inclusive finance development levels among the service stations. The mean value of the Village-level Service Station Construction Level (VS) is 4.1, accompanied by a standard deviation of 1.5, demonstrating significant variation in construction levels across the stations.

Table 1. Descriptive statistics

Variable	Mean	Standard deviation	Minimum	Maximum
RE	52.3	15.7	12.5	86.4
DPF	3.6	1.2	0.8	5.2
VS	4.1	1.5	1.3	6.8
GDP	25.7	8.3	10.2	41.5
PD	15.2	5.1	5.6	23.8
ED	2.8	0.9	1.2	4.5

As shown in **Table 2**, the Digital Inclusive Finance Development Level (DPF) exhibits a statistically significant positive impact on the Rural E-commerce Development Level (RE), with a coefficient of 0.783 and a P-value of < 0.001. This indicates that for every one-unit increase in DPF, the RE level increases by an average

of 0.783 units.

Similarly, the Village-level Service Station Construction Level (VS) also demonstrates a statistically significant positive impact on RE. The coefficient is 0.654 (P = 0.001), signifying that a one-unit increase in VS corresponds to an average increase of 0.654 units in RE.

The interaction term between Digital Inclusive Finance and Village-level Service Station (DPF × VS) shows a statistically significant positive effect on RE, with a coefficient of 0.421 (P = 0.007). This result confirms a significant synergistic effect between DPF and VS on the development of rural e-commerce.

Among the control variables:

(1) Economic Development Level (GDP) has a significant positive impact on RE (Coefficient = 0.235, P = 0.002).

(2) Population Density (PD) has a significant positive impact on RE (Coefficient = 0.123, P = 0.006).

(3) Education Level (ED) has a significant positive impact on RE (Coefficient = 0.187, P = 0.002).

The model's R^2 is 0.725, indicating that 72.5% of the variation in the dependent variable (RE) is explained by the model. This suggests a good model fit.

Table 2. Regression results

Variable	Coefficient	Standard error	*t* value	*P* value
DPF	0.783	0.215	3.642	0.000
VS	0.654	0.198	3.305	0.001
DPF × VS	0.421	0.157	2.681	0.007
GDP	0.235	0.078	3.013	0.002
PD	0.123	0.045	2.733	0.006
ED	0.187	0.062	3.016	0.002
Intercept	12.567	3.892	3.228	0.001
R^2		0.725		

3.4.2. Robustness tests

To assess the robustness of the model, this study conducted the following robustness tests:

Variable substitution: The dependent variable was replaced using the rural e-commerce transaction value instead of the rural online retail sales value. The regression results were broadly consistent with those of the original model.

Replacement of independent variables: The key independent variables were replaced:

(1) The Digital Inclusive Finance Development Level (DPF) was replaced by the volume of digital financial transactions.

(2) The Village-level Service Station Construction Level (VS) was replaced by the service quality of the service stations.

Regression analysis using these alternative measures yielded results broadly consistent with the original model.

Subsample regression: The sample was divided into high, middle, and low terciles based on indicators such as economic development level and population density. Regression analyses were performed separately on each

subsample. The results across these subgroups remained broadly consistent with those of the original model.

The findings from the robustness tests collectively indicate that the conclusions of the original model are robust. Specifically, it is robustly confirmed that:

(1) Digital inclusive finance exerts a significant positive impact on rural e-commerce development.

(2) The construction of village-level service stations has a significant positive impact on rural e-commerce development.

(3) The interaction between digital inclusive finance and village-level service stations exhibits a significant synergistic effect on rural e-commerce development.

4. Challenges and policy recommendations

4.1. Implementation barriers

As a key node city in the Beijing-Tianjin-Hebei coordinated development, Baoding's rural e-commerce development exhibits a dual characteristic of "distinctive features yet inadequate inclusiveness."

On the positive side, leveraging its unique agricultural products such as Fuping County's mushrooms and Wangdu County's peppers, alongside traditional handicrafts like Gaoyang's textile industry and Quyang's stone carving, Baoding has fostered the emergence of several county-level e-commerce clusters.

However, Baoding still faces multiple challenges:

(1) Mismatch between financial supply and demand: Traditional financial institutions struggle to adapt to the asset-light nature of e-commerce businesses. Their lending practices remain heavily reliant on collateral and guarantees.

(2) Weak digital infrastructure: Unstable 4G coverage persists in some mountainous counties like Fuping. Village-level financial service stations often offer limited functionality, hindering their ability to support the real-time transaction demands of e-commerce.

(3) Insufficient capabilities of market entities: Farmers exhibit varying levels of financial literacy, and trust barriers towards online credit products exist. Some groups still prefer borrowing through informal, acquaintance-based channels.

(4) Lack of industrial synergy: Supporting facilities such as cold chain logistics and brand marketing lag behind. This results in high distribution costs for agricultural products moving from rural to urban markets (agricultural product distribution).

4.2. The "One Core, Three Wings" Framework (Table 3)

(1) Deepen innovation in digital financial products: Design specialized financial products, such as e-commerce order financing and supply chain finance, tailored to regional characteristic industries like Baigou's leather goods and Gaoyang's textile industry. Develop credit instruments for characteristic industries, utilizing transaction flow data as an alternative to traditional collateral to shorten loan approval cycles.

Establish a rural e-commerce risk compensation fund to create a multi-tiered risk-sharing mechanism, providing partial risk compensation to financial institutions for e-commerce loans disbursed.

Explore the "insurance + futures" model to mitigate risks associated with agricultural product price volatility.

(2) Expand the functionality of village-level service stations: Deploy self-service credit terminals at service stations to offer real-time approval for small-amount credit loans, further reducing financing costs and embedding

financial services more deeply.

Develop "intergenerational collaboration" service models tailored to the aging population prevalent in mountainous counties.

Integrate county-level logistics resources to enhance delivery efficiency.

Conduct regular e-commerce operation skills training to cultivate versatile rural e-commerce entities, thereby improving the logistics and training systems.

(3) Build a tripartite collaboration mechanism: Integrate the data systems of finance, e-commerce, and service stations to establish a rural digital economy information hub.

Implement dynamic credit-granting strategies that automatically link increases in e-commerce sales data to credit line adjustments. Construct a data-sharing platform.

(4) Promote the "Finance + Service Station + E-commerce" model: Connect financial institutions with e-commerce operators through service stations, replicating successful models like "1 financial manager + N cloud warehouses" to amplify synergistic effects.

(5) Strengthen institutional safeguards: Establish an inter-departmental joint conference system to formulate financial function configuration standards for village-level service stations.

Incorporate the effectiveness of digital inclusive finance into the rural revitalization assessment system, strengthening policy coordination mechanisms.

Collaborate with universities for targeted training programs in "Finance + E-commerce" and establish village-level digital finance specialist positions supported by fiscal subsidies to enhance talent development.

(6) Explore an "insurance-guarantee" risk-sharing mechanism: Design multi-layered risk mitigation tools specifically for Baoding's e-commerce sector.

Drawing reference from models like MYbank's "Credit Village," establish a county-funded risk compensation fund (covering 30% of bad debt losses). Insurance companies should develop "e-commerce order insurance," and guarantee institutions should provide "light-asset credit enhancement" to form a comprehensive risk-sharing system.

Simulate and calculate the willingness of financial institutions to participate under different risk-sharing ratios.

Table 3. The "One Core, Three Wings" Framework

Component	Implementation strategy	Expected impact
Core: Industry-Finance Alignment	• Supply-chain financing for textile/cluster industries • Transaction-data-based credit scoring • "Insurance + Futures" price hedging	Reduce financing costs by 25–30%
Wing 1: Infrastructure Upgrade	• 4G/5G coverage in mountainous townships • Multifunctional VS with cold storage • Intergenerational digital assistants	Increase VS utilization by 40%
Wing 2: Policy Optimization	• Cross-departmental coordination mechanisms • Tax incentives for VS-finance integration • Provincial risk compensation fund (30% coverage)	Leverage 1:5 public-private investment
Wing 3: Capacity Building	• Village-level fintech specialists • Simulation training for elderly users • "Financial health" certification system	Increase digital adoption by 55%

5. Conclusion

The synergistic development of digital inclusive finance (DPF) and rural e-commerce (RE) has emerged as a crucial engine driving rural revitalization in Baoding. The study reveals a significant positive correlation between DPF development and RE growth: a one-unit increase in DPF drives a 78.3% increase in RE. This validates its core mechanisms of action through reducing financing costs, transaction costs, and operational costs (supporting H_1 and H_2).

Village-level service stations (VS) function as key infrastructure, significantly promoting RE development by providing logistics support, technical training, and market access services (supporting H_3). Crucially, a significant synergistic effect exists between DPF and VS (interaction term coefficient = 0.421, supporting H_4), demonstrating that their combination yields a "1+1>2" amplification effect. Additionally, regional economic development level, population density, and education level also exert positive influences on RE growth.

Looking ahead, leveraging strategic opportunities presented by the "Coordinated Development of the Beijing-Tianjin-Hebei Region" and the "Xiongan New Area construction," Baoding should focus on building a "One Core, Three Wings" support system [8]:

Core: Financial adaptation to characteristic industries, developing credit products tailored to industries like leather goods, textiles, and edible fungi.

Wings:

(1) Upgrading digital infrastructure (e.g., multi-functional village-level service stations).

(2) Optimizing policy coordination (e.g., combined support for cold chain logistics and finance).

(3) Building inclusive capabilities (e.g., promoting elderly-friendly technologies).

Concurrently, strengthening localized empirical research is essential. Through scientific evaluation and policy experimentation, Baoding can promote a higher-quality and more sustainable deep integration of digital inclusive finance and rural e-commerce. This path ultimately aims to achieve the goals of rural revitalization: increasing farmers' income, upgrading agriculture, and revitalizing rural areas [9].

Disclosure statement

The authors declare no conflict of interest.

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