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Research on the Integration and Innovation Model of New-Style Operational Entities in Old Revolutionary Areas Empowered by Digitalization: Based on Configuration Analysis

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Abstract: This paper focuses on the integrated innovation of new agricultural operators in old revolutionary base areas empowered by digitalization. Aiming at the problems of weak agricultural foundation, lagging digital transformation in these areas, and existing studies focusing on single factors while ignoring regional particularities, it conducts an empirical study using the fsQCA configurational analysis method. Defining core concepts such as digital empowerment, new agricultural operators and integrated innovation, it selects six conditional variables and uses 256 valid survey data from old revolutionary base areas like the Dabie Mountains and Jinggang Mountains to explore the driving mechanism of high-level integrated innovation. The study shows that no single condition is necessary for high-level integrated innovation; multiple factors form multiple equivalent paths, identifying four configurational models: synergistic-driven, leverage-incubated, environment-responsive and endogenous-led. Social network is the core cornerstone of all models, policy support plays a key role, and operator capability is context-dependent. Breaking through single-factor determinism, it reveals the complex causality and asymmetry of digital empowerment. Finally, corresponding countermeasures are proposed to provide theoretical and practical guidance for these areas to promote integrated innovation and rural revitalization through digital technologies.

Keywords: Digital Empowerment; New Agricultural Operators in Old Revolutionary Base Areas; Integrated Innovation; Models

1. Introduction

1.1 Research Background

With the accelerated application of a new generation of information technologies, the in-depth integration of digital technology with agriculture and rural areas has become the core driving force for the modernization of agriculture and rural areas, and has also injected new vitality into the rural revitalization of old revolutionary areas [1]. As a key supported area for rural revitalization, old revolutionary areas shoulder the dual mission of inheriting the red gene and promoting the high-quality development of agriculture. However, prominent problems such as weak agricultural foundation, single industrial structure, and insufficient development momentum still exist [2]. New-style agricultural operational entities (family farms, farmers' professional cooperatives, leading agricultural industrialization enterprises, etc.), as the core carriers of digital rural construction, are the key force to promote the transformation and upgrading of the agricultural industry and realize integration and innovation in old revolutionary areas.

Compared with developed areas, new-style agricultural operational entities in old revolutionary areas are faced with difficulties such as lagging digital transformation, insufficient internal vitality, and prominent innovation gaps: weak digital infrastructure, low technology popularization, and insufficient digital application capabilities of entities [3]; the interweaving of various influencing factors makes it difficult to form integration and innovation paths, and the dividends of digital empowerment have not been fully released. Against this background, focusing on "digital empowerment for the integration and innovation of new-style operational entities in old revolutionary areas" and solving development problems from a systematic perspective can not only activate the innovation vitality of entities, but also promote old revolutionary areas to achieve the goal of strong agriculture, beautiful countryside, and wealthy farmers [4].

In the process of digital empowerment, multiple factors such as policy support and resource endowments combine to form diverse institutional configurations, leading to complex causal relationship problems [5]. At present, relevant academic research mostly focuses on the impact of a single factor, fails to fully pay attention to the multi-factor synergy mechanism, and the impact of single factors and institutional structures on integration and innovation is still unclear. It is urgent to in-depth study the factor coupling relationship and overall behavior model to solve practical difficulties.

1.2 Research Significance

1.2.1 Theoretical significance

First, it enriches the research system of digital empowerment and the integration and innovation of new-style agricultural operational entities. By introducing the perspective of configuration analysis, it breaks through the limitations of single-factor analysis, reveals the concurrent causal relationship of multiple factors, and enriches research methods and perspectives. Second, it improves the research on agricultural innovation and development in old revolutionary areas, focuses on the special region of old revolutionary areas, and fills the gap in the research on integration and innovation models under digital empowerment. Third, it deepens the application of configuration analysis methods in agricultural economic research, applies the fsQCA method to this study, expands its application scenarios, and provides a reference for the research on similar complex problems.

1.2.2 Practical significance

First, it provides guidance for the integration and innovation of new-style operational entities, identifies effective configuration models, clarifies core and edge conditions, and helps entities choose adaptive paths according to their own endowments. Second, it provides a basis for the government to formulate supportive policies, clarifies the core role of policies, and provides suggestions for policy optimization, resource allocation, and infrastructure improvement. Third, it helps the implementation of the rural revitalization strategy, promotes industrial transformation and upgrading through digital empowerment, activates the endogenous motivation of rural areas, and promotes agricultural efficiency improvement and farmers' income increase.

1.3 Research Questions and Research Content

1.3.1 Research questions

The core is to solve two key questions: first, whether the six factors of policy support, resource endowment, social network, technical level, entity capability, and market environment are necessary conditions for high integration and innovation behavior; second, how these factors combine to form differentiated integration and innovation models, as well as their core logic and applicable scenarios.

1.3.2 Research content

It is carried out in accordance with the logic of "Introduction—Literature and Concept Definition—Research Methods—Analysis of Research Results—Conclusions and Countermeasures": first, the introduction part clarifies the research core and logic; second, literature and concept definition, combs the literature and defines core concepts; third, research methods, explains the rationality of the fsQCA method, research design and analysis steps; fourth, result analysis, identifies configuration models and interprets and compares them; fifth, conclusions and countermeasures, summarizes conclusions, puts forward suggestions, and points out deficiencies and prospects.

1.4 Research Ideas and Research Framework

1.4.1 Research ideas

Taking digital empowerment for the integration and innovation of new-style agricultural operational entities in old revolutionary areas as the core, clarify the theoretical basis and core variables through literature review; adopt the fsQCA method, take new-style operational entities in old revolutionary areas as the research object, collect survey data to identify high integration and innovation configuration models; interpret the models and compare differences to reveal the synergy mechanism; summarize conclusions and put forward countermeasures to provide reference for practice.

1.4.2 Research framework

Construct a framework of "Theoretical Foundation—Method Design—Empirical Analysis—Conclusions and Countermeasures": the first part (introduction) clarifies the research direction; the second part (literature and concept definition) lays the theoretical foundation; the third part (research methods) explains the design and steps; the fourth part (empirical analysis) interprets the configuration models; the fifth part (conclusions and countermeasures) summarizes the achievements and puts forward suggestions.

2. Literature and Concept Definition

2.1.1 Research on digital empowerment of agriculture

Digital empowerment is a process that takes digital technology as the core and promotes the transformation and upgrading of traditional industries through technology penetration and resource integration. Foreign research focuses on the application of digital technology in various links of agriculture and its impact on production efficiency and farmers' income [6]; domestic research focuses on combining with rural revitalization and industrial upgrading to explore empowerment paths and models [7]. Existing studies have shown that digital empowerment has a positive effect on agricultural development, but there is a lack of research on old revolutionary areas, which fails to take into account their regional particularities.

2.1.2 Research on integration and innovation of new-style agricultural operational entities

New-style agricultural operational entities have the characteristics of scale and intensification, and integration and innovation are reflected in the collaborative linkage between factors, industries and entities [8]. The academic circle generally believes that policy support, resource endowment and other factors are core influencing factors, and has identified various models such as industrial chain integration. However, most of them adopt single-factor analysis, fail to fully pay attention to multi-factor synergy, and have insufficient interpretation of the diversity of models [9].

2.1.3 Application of configuration analysis in agricultural economic research

Based on set theory and Boolean algebra, configuration analysis can effectively reveal the concurrent causal relationship of multiple factors and make up for the limitations of traditional regression methods. As a core tool, the QCA method has been gradually applied to fields such as agricultural industrial upgrading and the development of new-style operational entities, but it has not been applied to the research on the integration and innovation of new-style operational entities in old revolutionary areas empowered by digitalization [10].

Existing research has four deficiencies: first, the research perspective is limited, focusing on single-factor analysis and ignoring multi-factor synergy; second, the research areas are unbalanced, focusing on developed areas and ignoring the particularities of old revolutionary areas; third, the research methods are single, making it difficult to deal with complex causal relationships; fourth, the research content is not focused, lacking in-depth research on configuration models. This study will adopt the perspective of configuration analysis to make up for the above deficiencies.

2.2 Definition of Core Concepts

2.2.1 Digital empowerment

It specifically refers to the process of taking a new generation of digital technologies such as big data and artificial intelligence as the core, empowering the digital transformation of new-style operational entities in old revolutionary areas through infrastructure construction, technology popularization, talent training and other methods, optimizing resource allocation, and improving integration and innovation capabilities. Its core characteristics are technologization, collaboration and diversification.

2.2.2 New-style agricultural operational entities in old revolutionary areas

It refers to various operational entities engaged in agricultural production and operation within the scope of old revolutionary areas, with the characteristics of scale and specialization, which can drive the development of farmers. It mainly includes family farms, cooperatives, leading enterprises, etc., and its core characteristics are regionality, innovation and driving force.

2.2.3 Integration and innovation

Under the background of digital empowerment, it refers to the process in which new-style operational entities in old revolutionary areas integrate various factors, promote the collaborative linkage between agriculture, industry, service industry and other fields, and realize the innovation of production, operation and business models. Its core is reflected in the integration of factors, industries and entities.

2.2.4 Configuration analysis

This study adopts the fsQCA method, takes six factors as conditional variables and high integration and innovation behavior as the outcome variable, identifies the complex causal relationship between multi-factor combinations and outcomes, and reveals the integration and innovation configuration models. Its advantage is that it can handle concurrent causal relationships and reveal the phenomenon of "different paths leading to the same goal".

3. Research Methods

3.1 Selection of Research Methods

This study focuses on the impact of multi-factor combinations on integration and innovation, which belongs to the research on complex causal relationships. Traditional regression methods are limited to single-factor and linear causality, making it difficult to handle concurrent causality and the phenomenon of "different paths leading to the same goal"; while the fsQCA method combines the advantages of qualitative and quantitative analysis, can handle continuous variables through fuzzy set membership scores, is suitable for small and medium-sized sample analysis, and can effectively reveal the multi-factor synergy mechanism, so this method is selected. The specific basis is: first, it can handle the concurrent causal relationship of multiple factors; second, it adapts to the asymmetric causal characteristics; third, it is suitable for the limited sample data of this study.

3.2 Research Design

3.2.1 Setting of conditional variables and outcome variable

Outcome Variable (Y): High integration and innovation behavior of new-style operational entities in old revolutionary areas empowered by digitalization, which measures the degree of integration and innovation and is graded by fuzzy set scoring. Conditional Variables: Policy Support (A), Resource Endowment (B), Social Network (C), Technical Level (D), Entity Capability (E), Market Environment (F), which measure policy intensity, resource quality, cooperation capability, technical foundation, comprehensive capability and external support respectively.

3.2.2 Data sources

The data comes from field surveys of new-style operational entities in old revolutionary areas such as the Dabie Mountains and Jinggang Mountains. A combination of questionnaires and in-depth interviews was adopted. A total of 300 questionnaires were distributed, and 256 valid questionnaires were recovered, with an effective recovery rate of 85.33%, which meets the sample requirements of fsQCA. At the same time, secondary data was used for supplementary verification to ensure the authenticity and reliability of the data.

3.2.3 Variable calibration

The direct calibration method was adopted. Drawing on the practices of existing studies and combining with the distribution of survey data, the calibration thresholds of each variable were set as full membership (90th percentile), crossover point (50th percentile), and full non-membership (10th percentile), and fuzzy set membership scores between 0 and 1 were obtained, laying the foundation for subsequent analysis.

3.3 Analysis Steps and Parameter Setting

3.3.1 Analysis steps

The fsQCA 3.0 software was used, and the steps are as follows: first, variable calibration; second, necessity analysis to test whether a single condition is a necessary condition; third, construction of a truth table to screen effective condition combinations; fourth, configuration sufficiency analysis to identify high and non-high integration and innovation configuration models; fifth, interpretation and comparative analysis to reveal the synergy mechanism.

3.3.2 Parameter setting

The frequency threshold was set to 1, the raw consistency threshold to 0.8, and the PRI consistency threshold to 0.6 to ensure case coverage and analysis robustness. The intermediate solution was taken as the main analysis result, supplemented by the parsimonious solution to distinguish core conditions (appearing in both intermediate and parsimonious solutions) and edge conditions (appearing only in the intermediate solution). The validity of the configuration was evaluated through consistency and coverage.

4. Analysis of Research Results

The research necessity analysis shows that the consistency scores of all conditional variables are less than 0.9 (the highest is social network 0.87, policy support 0.82), indicating that a single condition is not a necessary condition for high integration and innovation. High integration and innovation require the collaborative combination of multiple factors, which verifies the rationality of the configuration analysis method. Under the set parameters, 5 high integration and innovation configurations (S1, S2, S3a, S3b, S4) were identified, among which S3a and S3b are second-order equivalent configurations, totaling 4 models.

4.1 Synergy-Driven Integration and Innovation Model (S1)

The configuration is "Policy Support * Technical Level * Social Network * Entity Capability", with a raw coverage of 0.600 and a unique coverage of 0.017. All four factors are core conditions, and the core logic is "policy guidance, technical support, entity leadership, and network collaboration", which is suitable for operational entities with strong policy inclination, solid technology, strong entity capabilities, and rich networks.

4.2 Leverage Incubation Integration and Innovation Model (S2)

The configuration is "Policy Support * Resource Endowment * Social Network", with the three as core conditions and the edge conditions as technical level (S2a) or market environment and entity capability (S2b). The raw coverage of S2a is 0.627, and that of S2b is 0.540. The core logic is "policy leverage, resource support, and network incubation", which is suitable for operational entities with rich resources, strong policy intensity, extensive networks, but weak technology and entity capabilities.

4.3 Environment-Responsive Integration and Innovation Model (S3)

The configuration is "Policy Support * Technical Level * Market Environment * Social Network", including two second-order equivalent sub-configurations with the same core conditions, a raw coverage of 0.600, and a unique coverage of 0.011. The core logic is "market traction, technology adaptation, policy guarantee, and network collaboration", which is suitable for operational entities with improved markets, high technology, in-place policies, and rich networks, especially suitable for old revolutionary areas in the suburban areas of cities.

4.4 Endogenous-Dominated Integration and Innovation Model (S4)

The configuration is "Resource Endowment * Technical Level * Social Network * Entity Capability", with the four as core conditions, a raw coverage of 0.612, and a unique coverage of 0.049. The core logic is "entity leadership, resource-driven, technical support, and network collaboration", which is suitable for operational entities with weak policy support but unique resources, high technology, strong entity capabilities, and rich networks. To further clarify the differences between configuration models, a comparative analysis of similar configuration models can be carried out as follows:

First, Comparison of Resource-Dependent Types (S2 and S4)

Both are based on resource endowment, but there are differences: S2 is policy-driven resource development, with entities participating passively and networks focusing on resource integration; S4 is entity-driven resource innovation, with entities taking the initiative to lead and networks focusing on collaborative innovation. S4 has realized the in-depth excavation of resource value and formed a sustainable model independent of external policies.

Second, Comparison of Technology-Driven Types (S1 and S3)

Both take technology as the core and rely on policies and networks, but their core logics are different: S1 is "policy-guided technology implementation", promoted from top to bottom, requiring entities to have policy understanding and technology integration capabilities; S3 is "market-driven technology adaptation", responding from bottom to top, requiring entities to have market insight and technology application capabilities, with different applicable scenarios.

Third, Comparison of Entity Capability Explicit Types (S1 and S4)

Both take entity capability as the core, but the sources of capability support are different: S1 relies on external empowerment to form a positive logic of "policy-technology-entity-network"; S4 relies on endogenous growth to form an endogenous logic of "resource-entity-technology-network", with applicable scenarios of comprehensive areas and potential areas respectively.

Fourth, Comparison of Entity Capability Implicit Types (S2 and S3)

The entity capabilities of both are implicit support, relying on networks to make up for shortcomings, but their innovation orientations are different: S2 is policy-oriented resource utilization, with technology as a basic tool and income relying on policies; S3 is market-oriented demand response, with technology as a core medium and income relying on the market, with different stability.

4.5 Discussion of Results

The integration and innovation of new-style operational entities in old revolutionary areas empowered by digitalization has five characteristics: first, the models are diverse and equivalent, reflecting "different paths leading to the same goal"; second, social networks are the necessary cornerstone, which are core conditions in all high integration and innovation configurations; third, policy support is crucial, which is a core condition in three models; fourth, the role of entity capability is context-dependent; fifth, the causal relationship is asymmetric, and the configurations of high and non-high integration and innovation are completely different. Digital empowerment is by no means "technology transplantation" or "policy blood transfusion", but the scientific combination of factors to activate the innovation gene.

5. Conclusions and Countermeasures

5.1 Research Conclusions

Using the fsQCA method, the core conclusions are drawn: first, high integration and innovation have multiple equivalence, forming 4 differentiated models; second, the role of entity capability is context-dependent, and the degree of manifestation depends on the external context; third, social networks and policy support are key supports with irreplaceability; fourth, the causal relationship is asymmetric, and the configurations of high and non-high integration and innovation are different; fifth, it breaks through "technological determinism" and "capability determinism", and the adaptive combination of factors is the key.

5.2 Policy Suggestions

Combining the core characteristics and applicable scenarios of the four integration and innovation models, targeted optimization countermeasures are put forward:

First, accurately adapt to the synergy-driven model and strengthen the synergy of policies, technology, entities and networks. Increase the intensity of precise policy support, improve digital infrastructure and technical training; build cross-entity collaborative networks to promote the transformation of technological achievements; cultivate the comprehensive capabilities of entities and improve the level of policy interpretation and technology integration.

Second, optimize the leverage incubation model and give play to the role of policy leverage and network incubation. Focus on the advantages of resource endowment and issue special policies for resource development; build resource integration networks to connect resources such as technology and markets; carry out targeted capacity training to incubate the innovation capabilities of entities and reduce the threshold of technology application.

Third, improve the environment-responsive model and strengthen market traction and technology adaptation. Improve the agricultural market system and build a market information docking platform; promote the adaptation of digital technology to market demand, and encourage entities to use big data, live streaming and other technologies to respond to the market; optimize policy supporting measures to provide guarantee for technology application and market docking.

Fourth, support the endogenous-dominated model and stimulate the endogenous innovation vitality of entities. Increase the intensity of technical support and talent training to improve the technology application and innovation capabilities of entities; improve the construction of social networks and support entities to build collaborative innovation communities; optimize the business environment to provide a relaxed space for the independent innovation of entities.

Fifth, strengthen the general support guarantee and lay a solid foundation for integration and innovation. Accelerate the construction of digital infrastructure in old revolutionary areas and expand the coverage of technology popularization; improve the social network system and promote the collaborative cooperation between entities, governments, scientific research institutions, etc.; establish a differentiated policy system to adapt to the needs of different models, promote the coordinated efforts of factors, and help the rural revitalization of old revolutionary areas.

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