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The Underlying Mechanisms and Implementation Pathways of New Quality Productive Forces in Empowering the High-Quality Development of Rural Industries: Based on a "Technology–Factors–Value" Analytical Framework

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Abstract: As an advanced form of productivity driven by technological innovation, new quality productive forces provide fundamental impetus for rural industries to break through traditional development bottlenecks and achieve high-quality growth. Based on a three-dimensional analytical framework of "technology-factors-value," this paper systematically elucidates the internal mechanisms by which new quality productive forces empower the high-quality development of rural industries. It delves into the practical challenges at the levels of technological adaptation, factor allocation, and value transformation, and proposes implementation paths including localized technological innovation, restructuring of the factor system, and improvement of institutional safeguards, aiming to provide references for the modernization of agriculture and rural areas.

Keywords: New quality productive forces; Rural industries; High-quality development; Data factors; Industrial integration

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1. Introduction

After the 20th National Congress of the Communist Party of China, new quality productive forces have become the core engine driving high-quality development. Marked by a substantial increase in total factor productivity, they aim to break free from the constraints of traditional productivity development paths through revolutionary technological breakthroughs, innovative allocation of production factors, and profound industrial transformation and upgrading. For rural industries, which have long been plagued by diminishing marginal returns on factors, short industrial chains, and low added value, new quality productive forces are driving profound systemic reshaping of their production methods, organizational forms, and value creation models. However, their current implementation in rural areas faces structural constraints from small-scale farming operations, factor shortages in digital talent and data ecosystems, as well as institutional barriers in industrial integration mechanisms and value distribution systems. Therefore, revealing the internal mechanisms by which new quality productive forces empower the high-quality development of rural industries, recognizing their practical challenges, and exploring targeted implementation paths hold significant theoretical value and practical implications for advancing the construction of an agricultural powerhouse and achieving comprehensive rural revitalization.

2. The internal mechanism of empowering high-quality development of rural industries with new quality productive forces

The empowerment of rural industries by new quality productive forces represents a collaborative process involving technological iteration, factor activation, and value reshaping, driving agriculture towards data-driven transformation, factor allocation reform, and value chain ascension.

2.1. Technological innovation empowerment: Promoting the intelligent and efficient iteration and upgrade of traditional agricultural production

The technological core of new quality productive forces is manifested in the cross-integration and clustered breakthroughs of next-generation information technology, biotechnology, new material technology, and advanced manufacturing technology. When these technological clusters penetrate the agricultural production sector, they first trigger intelligent transformations in production methods. The integrated application of the Internet of Things (IoT), remote sensing monitoring, and artificial intelligence algorithms enables agricultural production to shift from passive responses reliant on weather conditions to precise decision-making based on weather forecasts [1]. Taking intelligent agricultural machinery and equipment as an example, the combination of autonomous driving, precision planting, and variable-rate fertilization technologies not only reduces labor input per unit area but also achieves ecological corrections to marginal output by minimizing excessive use of chemical fertilizers and pesticides. Furthermore, gene editing and molecular design breeding technologies within biotechnology are reshaping the technological paradigm for agricultural variety improvement, enabling synergistic enhancements in crop stress resistance, nutritional quality, and yield potential. The collaborative development of smart agriculture, biological agriculture, and equipment agriculture, catalyzed by this technological innovation, essentially represents a leapfrog substitution of traditional agricultural technological trajectories. By enhancing total factor productivity, it drives rural industries out of the growth trap characterized by "high input, high consumption, and low efficiency," achieving iterative upgrades towards efficiency and greenness.

2.2. Factor restructuring empowerment: Activating the potential of traditional rural production factors through data elements

A notable feature of new quality productive forces lies in the innovative allocation of production factors, with the rise and penetration of data elements being particularly crucial. In classical growth theory, land, labor, and capital are considered the three traditional factors of agricultural production. However, under long-term rigid allocation, these factors generally face dilemmas of diminishing marginal returns and low allocation efficiency. As a core component of new quality productive forces, data elements possess characteristics of non-rivalry, low marginal cost, and strong permeability, enabling them to deeply embed within traditional factor systems and activate latent potential through information empowerment and connectivity empowerment [2]. Specifically, the integration of data elements with land factors has spawned novel applications such as soil moisture monitoring, field-level yield mapping, and digital archives of cultivated land quality, shifting land management from extensive empirical approaches to refined digital governance. The combination of data elements with labor factors, through agricultural knowledge graphs, expert systems, and remote diagnostic platforms, encodes and externalizes implicit agricultural knowledge, effectively alleviating the skills gap amid an aging rural workforce. The integration of data elements with capital factors, through the digitization of agricultural supply chains and rural credit systems, reduces information asymmetry and risk premiums for financial capital entering the agricultural sector. Productivity development depends not only on the quantity of factor inputs but also on the combination and allocation efficiency of factors. The introduction of data elements breaks the closed-loop state of traditional rural factors, achieving multiplicative and synergistic amplification of traditional production factors by constructing a conversion chain of "data-information-knowledge-decision," thereby reshaping the production possibility frontier of rural industries.

2.3. Value ascension empowerment: Driving rural industries from low-end supply to high-end value transformation

Rural industries have long faced structural dilemmas of being "locked in" at the low end of the value chain, with agricultural production predominantly staying on the stage of primary product supply, characterized by low added value, high market risks, and weak brand premiums [3]. New quality productive forces, through dual drivers of technological innovation and business model innovation, propel rural industries to break through single production functions and extend into high-value-added links such as research and development, processing, services, and brand operations, achieving fundamental value from ascension. On one hand, digital technology-enabled agricultural product quality traceability systems, intelligent grading and sorting systems, and e-commerce direct procurement platforms compress circulation links, enhance market recognition and pricing power for high-quality agricultural products, enabling the realization of "quality premiums" and "trust premiums." On the other hand, the integration of biotechnology, food science, and intelligent manufacturing technologies drives the deep processing of agricultural products towards high-value directions such as functional foods and bio-based materials, extending the industrial chain and elevating the value chain position. More importantly, new quality productive forces have spawned new business models for rural industry convergence. The rise of smart cultural tourism, creative agriculture, and agricultural experience models integrating primary, secondary, and tertiary industries has transformed rural industries from mere providers of material products into composite providers of ecological services, cultural experiences, and leisure consumption. The essence of this value ascension is the dual enhancement of use value and exchange value for rural industries supported by technological innovation, representing a systemic transformation from "selling raw materials" to "selling products," "selling services," "selling brands," and even "selling standards."

3. Practical dilemmas in empowering high-quality development of rural industries with new quality productive forces

Although the empowerment of new quality productive forces holds theoretical inevitability, it still encounters structural obstacles in rural contexts. These practical impediments are rooted in the real-world shortcomings of small-scale farming, human capital, and institutional supply, creating stark tensions with the aforementioned three mechanisms.

3.1. Technological adaptation dilemma: Insufficient integration of cutting-edge digital technologies with small-scale farming models

Currently, the research and development of digital technologies for agriculture and rural areas often presuppose large-scale application scenarios, structurally misaligned with China's predominant small-scale farming landscape characterized by fragmented and dispersed plots, posing the primary obstacle to the implementation of new quality productive forces. Specific manifestations include: firstly, the high initial investment costs of intelligent agricultural machinery and IoT equipment, which are unaffordable for small-scale farmers, coupled with the immaturity of existing socialized service systems in providing small-scale and precision services, resulting in limited technological accessibility. Secondly, the strong heterogeneity of small-scale farming operations, with significant variations in crops, plots, and seasons, contrasts with the general-purpose nature of existing digital solutions, which lack modular and lightweight adaptations for small-scale farmers, reducing technological usability. Thirdly, the generally low digital literacy among small-scale farmers limits their ability to accept and operate complex technological systems, facing high learning costs. Research indicates that the success of agricultural technology diffusion depends not only on technological advancement but also on its compatibility with existing socio-technical regimes. When cutting-edge digital technologies fail to effectively embed within the institutional context and cognitive frameworks of small-scale farming, they easily fall into a "technological suspension" dilemma—physically present but not truly integrated into production processes, struggling to translate into sustained productivity.

3.2. Factor shortage dilemma: Shortage of rural digital talent and lagging ecosystem construction for data elements

Activating traditional production factors through data elements requires effective collection, governance, circulation, and application as prerequisites. However, rural areas exhibit obvious shortcomings in this regard. On one hand, there is a severe shortage of rural digital talent. New quality productive forces require not only technology "users" but also "new farmers" proficient in analysis and operation and maintenance. Affected by the outflow of young and middle-aged populations, the digital skills and innovation management capabilities of the existing rural workforce struggle to meet new technological requirements. Coupled with inadequate incentive mechanisms for returning talent, issues of "unable to attract, insufficiently cultivate, unable to retain, and ineffective utilization" are prominent [4]. On the other hand, the ecosystem construction for rural data elements lags behind. Agricultural data sources are scattered, standards are inconsistent, and quality is poor, while rural network, storage, and computing infrastructure are weak, with low levels of automated collection and standardized processing. Simultaneously, rules for data property rights delineation, pricing, and circulation are still being explored, and the lack of sharing mechanisms leads to widespread "data silos," with low willingness and trust levels among agricultural entities to share data, resulting in inefficient market allocation. This dual lag in talent and data ecosystems prevents the release of the multiplicative effects of data on traditional factors, leaving the factor restructuring empowerment of new quality productive forces facing a "no rice to cook" dilemma.

3.3. Value transformation dilemma: Inadequate supply of industrial convergence mechanisms and value distribution systems

The value ascension of rural industries highly relies on deep industrial convergence and reasonable benefit distribution systems, both of which currently exhibit obvious shortcomings. In terms of convergence mechanisms, the integration of primary, secondary, and tertiary industries often remains at the level of simple physical space juxtaposition, lacking the "chemical reaction" based on technological coupling and value chain synergy. The absence of cross-industry technical standards, quality norms, and digital connection platforms leads to severe homogenization of convergence business models and fragmented consumer experiences, struggling to form sustainable competitiveness. In terms of distribution systems, benefit linkage mechanisms are generally loose, with farmers often participating as land lessors, raw material suppliers, or seasonal workers, unable to share in service revenues such as processing value-addition and brand premiums. The severely imbalanced bargaining power between leading enterprises and farmers limits the coverage of contractual and equity-based close linkage methods, resulting in insufficient embedding depth of farmers in the value chain and the risk of being "crowded out" from high-value-added links. Institutional economics posits that institutional quality is the core factor determining a country's long-term economic performance and stability [5]. When convergence mechanisms lack deep synergy and distribution systems lack fair safeguards, the value increments generated by new quality productive forces struggle to be reasonably shared within rural areas, significantly undermining the inclusiveness and sustainability of high-quality industrial development.

4. Implementation paths for empowering high-quality development of rural industries with new quality productive forces

To address the aforementioned dilemmas, it is essential to transcend a singular technological logic and construct a synergistic systemic solution integrating "technology-factors-institutions." Path design should adhere to a problem-oriented approach, grounded in local characteristics, to ensure that new quality productive forces truly take root in rural areas and benefit farmers.

4.1. Focusing on adaptive implementation: Promoting localized, low-cost innovation and application of new agricultural technologies

The key to resolving the technological adaptation dilemma lies in shifting agricultural technological innovation from a "laboratory logic" to a "field logic," closely aligning with the practical constraints of small-scale farming and establishing a localized and low-cost orientation. In terms of technological routes, lightweight, modular, and miniaturized intelligent equipment should be developed, along with micro-agricultural machinery and portable devices suitable for hilly and fragmented plots, and "light applications" based on mobile terminals should be advanced to simplify complex decision-making models into user-friendly interfaces. Regarding product forms, enterprises should be encouraged to provide integrated solutions combining "hardware + services + data," reducing initial farmer investment through flexible models such as leasing, trusteeship, and pay-per-use. In terms of service models, the digital transformation of grassroots agricultural technology extension systems should be strengthened, digital technology instructors in rural areas should be cultivated, and a tiered transmission mechanism of "experts-technicians-demonstration households-farmers" should be established to reduce social costs through neighborhood demonstrations. The core of appropriate technology lies in its alignment with local resource endowments and human capital. Only by making technology truly "attuned to rural realities" and "understanding agricultural conditions" can it penetrate the structural barriers of small-scale farming and achieve a fundamental transformation of new quality productive forces from "technological suspension" to "technological rooting."

4.2. Addressing factor shortages: Constructing a system for talent agglomeration and efficient allocation of data elements

Addressing factor shortages requires a "dual-wheel drive" approach focusing on both talent and data. On one hand, rural talent system reforms should be deepened to establish a comprehensive mechanism for attracting, cultivating, retaining, and utilizing talent. Relying on agricultural universities, interdisciplinary programs such as smart agriculture should be offered, and "order-based" talent cultivation should be implemented; simultaneously, support for returning entrepreneurs should be improved, with preferences given to digital talent in financing, social security, and professional title evaluations. Additionally, actions to enhance farmers' digital literacy should be implemented, transforming traditional farmers into "new farmers" and achieving a balance between "stock transformation" and "incremental introduction" of talent. On the other hand, the underlying ecosystem for efficient allocation of data elements should be constructed. Information infrastructure in rural areas, such as 5G and the Internet of Things, should be upgraded; agricultural data resource catalogs and classification systems should be established, with unified standards for collection, storage, and trading to break down "data silos." Critically, mechanisms for separating agricultural data property rights should be explored, clarifying holding, usage, and operational rights, and regional data trading centers should be cultivated to promote the safe and orderly flow of data through market-based mechanisms. Only in this way can it be ensured that data is "collectable, manageable, flowable, and usable," enabling its multiplicative effect on traditional factors to transition from theory to practical productive forces.

4.3. Improving institutional guarantees: Deepening cross-industry integration and enhancing value-based benefit linkage mechanisms

Value transformation relies on institutional guarantees. In terms of industrial integration, the shift from physical juxtaposition to chemical integration should be promoted, with digital platforms connecting agricultural value chains with processing, cultural tourism, health and wellness, and other sectors. Regional integration service platforms should be established to integrate functions such as production, traceability, and marketing for integrated operations; technical standards and quality certification systems should be formulated to enhance the credibility of integrated products; and cooperation among scientific enterprises, platforms, and collective economic organizations should be encouraged to create demonstration models with technical depth and complete chains. Regarding benefit linkages, efforts should be made to enhance farmers' embedding depth and bargaining power. The "leading enterprise + cooperative + farmer" model should be promoted, encouraging farmers to become value-sharing participants through equity contributions of land, capital, and other factors, and developing close linkages such as equity cooperation and guaranteed dividends. The coordinating function of collective economic organizations should be strengthened to uniformly engage with markets and negotiate distributions, enhancing collective bargaining power through organization. The government should improve fiscal, tax, and financial policies to preferentially support entities with strong driving capabilities and establish monitoring and correction mechanisms for value distribution to ensure that the incremental value created by new quality productive forces benefits rural communities and farmers more extensively.

5. Conclusion

New quality productive forces have opened up new spaces for the high-quality development of rural industries. Research indicates that they systematically reshape rural industries through three mechanisms: technological innovation, factor restructuring, and value ascension. However, the empowerment process faces practical dilemmas such as technological adaptation, factor shortages, and value transformation. In response, a systemic perspective should be maintained, pursuing localized technological adaptation in innovation, emphasizing a "dual-wheel drive" of talent and data in factor cultivation, and deepening industrial integration and benefit sharing in institutional supply. Only by coordinating technology, factors, and institutions can theoretical potential be transformed into developmental momentum, providing strong support for building an agricultural powerhouse and revitalizing rural areas.

Disclosure statement

The authors declare no conflict of interest.

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