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Innovation Mechanism and Development Optimization Path of the Integration and Synergy between Digital Economy and E-commerce

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Abstract

The in-depth integration and synergy between the digital economy and e-commerce serves as the core pathway for digital technologies to empower the real economy, reshape the circulation system, and stimulate market vitality, as well as a key grip for promoting high-quality economic development. Supported by the industrial convergence theory, transaction cost theory, innovation diffusion theory, and data factor theory, this paper constructs an integrated analytical framework of "technology empowerment–scenario expansion–ecological synergy–governance guarantee". It systematically explains the internal logic and innovation mechanism of the integration and synergy between the digital economy and e-commerce. Combined with authoritative statistical data and industry practices from 2024 to 2025, this paper sorts out the practical effects of integrated development from the dimensions of technology application, scenario expansion, infrastructure, cross-border trade, and digital transformation of small and medium-sized entities, and deeply analyzes the practical obstacles such as unbalanced layout of digital infrastructure, blocked digital transformation of small and medium-sized enterprises, prominent cross-border compliance risks, hidden dangers of data security, inadequate supervision adaptation, and lagging green development. On this basis, it puts forward a systematic optimization path from six dimensions: balanced layout of infrastructure, all-round empowerment of small and medium-sized enterprises, risk prevention and control of cross-border e-commerce, construction of data security system, innovation of supervision mechanism, and green and low-carbon transformation, so as to provide theoretical reference and practical support for promoting the in-depth integration, collaborative innovation, and high-quality development of the digital economy and e-commerce.

Keywords

Digital economy, E-commerce, Integrated synergy, Innovation mechanism, Optimization path, High-quality development

1. Introduction

1.1 Research Background

The global wave of digitalization continues to deepen, and the digital economy has become the core force reshaping the global economic pattern and shaping new advantages in industrial competition. The large-scale application of digital technologies such as artificial intelligence, big data, cloud computing, and blockchain has triggered fundamental changes in the allocation of production factors, commodity circulation models, and consumption service forms. As the most active application format of the digital economy, e-commerce has achieved leapfrog development from scale expansion to quality improvement. Relying on sound digital infrastructure, a huge market size, and a vibrant innovation ecosystem, China ranks among the world's first echelons in the development of the digital economy and e-commerce, forming an industrial pattern that covers all people, connects urban and rural areas, and links the world.

Data shows that in 2024, the added value of China's digital economy core industries accounted for 10.5% of GDP, and this proportion continued to rise in 2025; China's total data production reached 41.06 zettabytes in 2024. By the end of 2025, the total number of 5G base stations reached 4.838 million, the 5G coverage rate of administrative villages reached 95%, and the total computing power scale exceeded 300 EFLOPS, ranking second in the world. The e-commerce sector has expanded simultaneously: in 2025, China's online retail sales reached 15.97 trillion yuan, and the proportion of online retail sales of physical goods in total retail sales of consumer goods stabilized at more than 26%; the total import and export volume of cross-border e-commerce reached 2.75 trillion yuan, accounting for about 6% of total foreign trade, becoming an important engine for stabilizing foreign trade. At the policy level, top-level designs such as the Overall Layout Plan for Digital China Construction and the 14th Five-Year Plan for Digital Economy Development have been issued intensively, providing institutional guarantee for the integration and synergy of the two sectors[1].

However, behind the rapid development, structural contradictions and institutional obstacles remain prominent: there are significant regional and urban-rural gaps in digital infrastructure, with insufficient coverage in central and western regions and rural areas; small and medium-sized enterprises (SMEs) face triple constraints of capital, technology, and talents in digital transformation; cross-border e-commerce encounters multiple risks such as international compliance, geopolitics, and logistics fluctuations; there are regulatory gaps in new formats such as live-streaming e-commerce and social e-commerce; problems such as data leakage, big data-enabled price discrimination, and privacy abuse occur frequently; shortcomings in green transformation such as express packaging pollution and high-carbon logistics are prominent. These problems restrict the depth and efficiency of integration and synergy, and a systematic solution is urgently needed.

1.2 Research Significance

Theoretical significance: This paper clarifies the core logic of the integration and synergy between the digital economy and e-commerce, improves the four-dimensional analysis framework of "technology–scenario–ecology–governance", defines the empowerment mechanism of digital technologies for the entire e-commerce industrial chain, enriches the application scenarios of industrial synergy theory in the digital economy field, provides empirical support for cross-research on the integration of digital economy and real economy, and expands the theoretical boundary of relevant research.

Practical significance: The research conclusions can provide decision-making reference for the government to improve industrial policies and innovate supervision models; provide implementable operation paths for the digital transformation of e-commerce platforms and traditional enterprises; provide solutions for SMEs to break through transformation dilemmas and cross-border e-commerce to avoid operational risks, help the standardized and orderly development of e-commerce, and enhance the international competitiveness of China’s digital trade.

1.3 Research Methods and Data Sources

Research methods: Literature research method: systematically sort out policy documents, core journal papers, and industry reports in the fields of digital economy, e-commerce, and industrial synergy to lay a theoretical foundation; Data analysis method: integrate official statistical data from the National Bureau of Statistics, Ministry of Industry and Information Technology, Ministry of Commerce, and industry association reports, and improve the credibility of conclusions through data cross-validation; Case analysis method: select typical domestic and foreign e-commerce platforms and enterprises to analyze the practical models and experience enlightenment of integration and synergy; Logical deduction method: deduce the innovation mechanism and optimization path of integration and synergy based on theories such as industrial convergence and transaction cost.

2. Core Concepts and Theoretical Basis

2.1 Definition of Core Concepts

Digital economy: Digital economy is a new type of economic form. It regards data as the crucial production factor, takes modern digital technologies as the major driving force, and relies on digital infrastructure as an important supporting carrier. It mainly includes two key aspects: digital industrialization and industrial digitalization. By virtue of the empowering role of data elements, it can realize the optimization of resource allocation, the improvement of social production efficiency and the overall optimization of economic structure.

E-commerce: E-commerce is a new business format that relies on digital network platforms such as the Internet and the Internet of Things to realize the online operation of the entire process of commodity trading, service provision, payment and settlement, as well as logistics distribution. It covers a variety of mainstream operation modes including B2B, B2C, C2C, cross-border e-commerce, live streaming e-commerce and social e-commerce, and serves as the core application carrier and typical scenario of the

digital economy in the field of commercial circulation.

F-Integrated synergy: A dynamic development process that takes digital technology as a link to promote the in-depth coupling of the technological and data advantages of the digital economy with the scenario and channel advantages of e-commerce, and realize resource sharing, value co-creation, and risk sharing among the industrial chain, which is the core form of the two sectors shifting from parallel development to symbiotic development.

2.2 Theoretical Support

Industrial convergence theory: Digital technologies break the boundaries of traditional industries, promote the in-depth penetration of e-commerce with manufacturing, agriculture, and service industries, give birth to new formats and models, and achieve industrial value multiplication, which is the core theoretical basis for integrated synergy.

Transaction cost theory: Digital technologies can effectively reduce the degree of information asymmetry in market transactions, simplify the overall transaction process, optimize various transaction and performance links, greatly lower transaction costs including market information search, business negotiation and contract performance, and further improve the overall operational efficiency of the e-commerce industry.

Innovation diffusion theory: The continuous diffusion of digital technology innovation achievements in the e-commerce field promotes the iterative upgrading of business models, operation models, and service models, and accelerates the overall transformation of the industry.

Data factor theory: As a new production factor, data integrates with traditional factors such as labor, capital, and technology to improve total factor productivity, becoming the core driving force for integrated synergy[6].

3. Innovation Mechanism of the Integration and Synergy between Digital Economy and E-commerce

The integration and synergy between the digital economy and e-commerce is not a simple superposition of technologies and splicing of business formats, but forms four core innovation mechanisms: technology empowerment, scenario expansion, ecological synergy, and factor activation, which jointly promote the high-quality development of the industry.

3.1 Technology Empowerment Mechanism: Whole-Chain Efficiency Improvement

Digital technologies run through the entire e-commerce industrial chain including R&D, production, marketing, logistics, and after-sales service, realizing the digital and intelligent upgrading of the whole process. At the front-end, big data and artificial intelligence are used to accurately portray user portraits and personalized recommendations to improve marketing conversion rates; at the middle-end, cloud computing and Internet of Things optimize supply chain scheduling to realize flexible production and accurate inventory control; at the back-end, smart logistics and blockchain traceability reduce distribution costs and ensure commodity quality. Intelligent recommendation algorithms increase the conversion rate

of e-commerce platforms by an average of 15%, and smart logistics reduce logistics costs by 18%. Technology empowerment has become a key variable for industry differentiation[4].

3.2 Scenario Expansion Mechanism: Cross-Domain Boundary Extension

E-commerce has broken through the boundary of traditional commodity retail and extended to industrial e-commerce, rural e-commerce, fresh food e-commerce, local life services, remote services and other fields, forming a diversified scenario pattern of "e-commerce + industry". In 2025, rural online retail sales exceeded 3 trillion yuan for the first time, and the transaction scale of new formats such as cross-border e-commerce and live-streaming e-commerce continued to rise. Scenario expansion continuously activates incremental markets and enriches the supply system.

3.3 Ecological Synergy Mechanism: Whole-Industrial-Chain Value Co-creation

With leading e-commerce platforms as the core, a full industrial chain ecosystem covering suppliers, producers, distributors, logistics enterprises, financial institutions, and consumers is built to realize real-time data sharing between the demand side and the supply side. The platform opens up technology, channel, and data resources to drive the coordinated development of SMEs. The industrial chain shifts from linear collaboration to network integration, and the efficiency of resource allocation has achieved a qualitative improvement.

3.4 Factor Activation Mechanism

The circulation and application of data elements can facilitate the precise matching between market supply and demand, optimize internal production procedures, and enhance the overall efficiency of industry supervision. Meanwhile, it can fully stimulate the inherent vitality of traditional production factors including labor, capital and technology. Data-supported precise decision-making, intelligent operational management and systematic risk prevention have become the core driving force for integrated synergy development, which further drives the transformation of the e-commerce industry from the traditional scale expansion mode to a new data-driven development mode.

4. Practical Effects of the Integration and Synergy between Digital Economy and E-commerce

4.1 Remarkable Effects of Technology Empowerment and Sustained Improvement of Industry Efficiency

Generative artificial intelligence, big data analysis, intelligent customer service, blockchain traceability and other technologies are widely used in the e-commerce field. From 2014 to 2023, China’s application for generative artificial intelligence patents ranked first in the world. New formats such as live-streaming e-commerce and social e-commerce have risen rapidly, with transaction scales exceeding 5 trillion yuan in both 2024 and 2025, forming a new consumption ecosystem of "content + transaction". The revenue growth rate of e-commerce enterprises with in-depth application of digital technologies is significantly higher than that of traditional e-commerce enterprises.

4.2 Continuous Expansion of Scenarios and Sustained Expansion of Market Scale

E-commerce has penetrated into all industries. In 2025, China’s online retail sales reached 15.97 trillion yuan, and the total import and export volume of cross-border e-commerce reached 2.75 trillion yuan;

rural e-commerce has broken the bottleneck of agricultural products going out of villages, with online retail sales increasing by 6.7% year-on-year; industrial e-commerce and service e-commerce have accelerated development, and diversified scenarios have promoted the continuous expansion of market boundaries.

4.3 Improved Infrastructure and Enhanced Supporting Capacity

In terms of digital infrastructure, 5G networks, gigabit broadband, and computing power hubs have been accelerated, with 95% 5G coverage of administrative villages, and the new computing power of eight national computing power hubs accounting for more than 60%, providing computing power support for the efficient operation of e-commerce; in terms of logistics infrastructure, there are more than 1,500 county-level e-commerce logistics distribution centers, township express outlets achieve full coverage, the rural logistics network is improved, and the loss rate of agricultural products e-commerce has dropped significantly.

4.4 Rise of Cross-border E-commerce and Strong Momentum for Foreign Trade Growth

Cross-border e-commerce has become a new engine for foreign trade. In 2025, its total import and export volume accounted for about 6% of total foreign trade, with a year-on-year growth of over 10%. Overseas warehouses cover major global markets, and the timeliness of cross-border logistics has been shortened by an average of more than 30%; countries co-building the "Belt and Road" have become core markets, and SMEs have conveniently gone global with the help of cross-border e-commerce, broadening international market channels[2].

4.5 Accelerated Transformation of SMEs and Prominent Inclusive Effects

Driven by policy support and platform empowerment, the cloud adoption rate of SMEs has continued to rise. In 2025, the numerical control rate of key processes of industrial SMEs above designated size exceeded 65%. The revenue growth rate of SMEs realizing full-process digital operation exceeded 10%, higher than that of non-transformed enterprises; e-commerce platforms have launched low-cost digital tools, skill training and other services, promoting digital transformation from "exclusive to large enterprises" to "inclusive for SMEs"[5].

5. Practical Obstacles and Restricting Factors of Integrated and Synergistic Development

5.1 Unbalanced Regional Layout of Digital Infrastructure

There are significant regional and urban-rural gaps in digital infrastructure: the 5G coverage rate of administrative villages in the eastern region is much higher than that in some western regions, and the rural network stability is insufficient; the cold chain logistics of agricultural products has prominent shortcomings. In 2023, the comprehensive low-temperature treatment rate of national agricultural production areas was only 32%, and the loss rate of fresh food e-commerce reached 15%–20%; the construction of logistics hubs in the central and western regions lags behind, restricting balanced regional development.

5.2 Prominent Difficulties in Digital Transformation of SMEs

SMEs face three dilemmas of "unable to transform, dare not transform, and unwilling to transform": in terms of capital, digital investment accounts for less than 5% of revenue, and financing difficulties and high financing costs are prominent; in terms of technology, there is a lack of professional teams and weak application ability of digital tools; in terms of talents, there is a shortage of compound digital talents, college training is disconnected from enterprise needs, and the problems of difficult recruitment and retention are common.

5.3 Prominent Compliance and Operational Risks of Cross-border E-commerce

Cross-border e-commerce faces multiple risks such as differences in international policies, geopolitics, and operational fluctuations: in terms of compliance, policies on intellectual property protection, data security, and tax supervision vary greatly among countries and regions, and compliance costs have risen significantly; in terms of operation, problems such as fluctuating cross-border logistics costs, payment fraud, and overstocked overseas warehouses occur frequently; SMEs have weak risk resistance and are difficult to cope with the complex international market environment.

5.4 Prominent Problems of Data Security and Privacy Protection

Problems such as data leakage, abuse, and big data-enabled price discrimination occur frequently in the e-commerce field, and information leakage has become the focus of user complaints; some platforms have insufficient data protection capabilities, non-standard storage, and backward encryption technologies; the implementation of data security laws and regulations is insufficient, and the cost of violations is low; there is a lack of unified standards for data transactions, and the security and compliance of data circulation are difficult to guarantee.

5.5 Inadequate Adaptation of Industry Standards and Supervision System

The e-commerce industry lacks unified technical, service, and data standards, and data interconnection between platforms is blocked; there are regulatory gaps in new formats such as live-streaming e-commerce and social e-commerce, and problems such as false publicity, fake transactions, and counterfeit and shoddy products are prominent. In 2024, the number of complaints and reports on live-streaming sales increased by 19.3% year-on-year; the traditional supervision model is difficult to adapt to the cross-regional, real-time characteristics of e-commerce, the application of smart supervision is insufficient, and the supervision efficiency is low.

5.6 Lagging Green and Low-Carbon Development Level

The e-commerce industry generates a massive volume of express packaging waste, which is accompanied by a low resource recycling rate. The extensive use of disposable plastic packaging has resulted in severe environmental pollution. Furthermore, the market share of green products remains relatively low, and consumer willingness toward green consumption is generally inadequate. The popularization and application of new energy logistics vehicles have progressed sluggishly, leading to persistently high carbon emission intensity within the logistics distribution sector. In addition, the absence of a standardized evaluation system for green e-commerce has further weakened the endogenous incentive

for enterprises to pursue green and low-carbon transformation.

6. Optimization Path for the Integrated and Synergistic Development of Digital Economy and E-commerce

6.1 Optimize the Balanced Layout of Digital Infrastructure to Narrow Regional and Urban-Rural Development Gaps

In the context of deep integration between the digital economy and e-commerce, unbalanced distribution of digital and logistics infrastructure has long restricted the coordinated development among regions and between urban and rural areas [7]. Therefore, it is urgent to promote the comprehensive extension of digital infrastructure to central and western regions as well as vast rural areas, systematically implement the upgrading project of “Digital Countryside”, and continuously enhance the coverage rate, network speed and operational stability of rural communication and broadband facilities. Meanwhile, it is necessary to further optimize the national computing power spatial layout, accelerate the scale construction of major computing power hubs and node centers in central and western regions, and facilitate the reasonable flow and balanced allocation of intelligent computing power resources across the country. In terms of circulation support, governments at all levels should improve the integrated three-level logistics service system covering counties, townships and villages, strengthen the cold chain logistics infrastructure construction in major agricultural producing areas, actively advocate the popularization of recyclable packaging materials and shared express container modes, so as to effectively reduce commodity circulation costs and logistics loss rates. In addition, relevant policies should be introduced to encourage and guide social capital to actively participate in infrastructure investment and operation in economically underdeveloped and remote rural areas, and establish a standardized and sustainable long-term incentive and benefit-sharing mechanism to consolidate the foundation for coordinated innovation between digital economy and e-commerce.

6.2 Empower SMEs in an All-Round Way to Solve the Dilemma of Digital Transformation

In terms of capital, set up special funds for digital transformation of SMEs, implement tax incentives and loan interest discounts to reduce financing costs; in terms of technology, build a digital technology sharing platform, promote "small, fast, light, and accurate" standardized solutions, and e-commerce platforms open up data and technical resources; in terms of talents, build a collaborative education mechanism of "universities + enterprises + associations", carry out digital skills training, and improve talent incentive policies; in terms of demonstration, cultivate transformation benchmarks, summarize replicable models, and guide SMEs to carry out orderly transformation.

6.3Improve the Risk Control System of Cross-border E-commerce to Expand International Market Space.To expand international market space and promote high-quality development, cross-border e-commerce must build a comprehensive risk control system covering compliance, logistics, risk early warning and market expansion. In terms of compliance services, governments and industry associations should jointly build a one-stop compliance platform, providing professional guidance on intellectual

property protection, international taxation and cross-border legal norms, which helps enterprises effectively reduce compliance costs and regulatory risks in transnational operations. In terms of logistics optimization, it is necessary to increase policy and financial support for overseas warehouse construction, realize full coverage of core overseas markets, and develop a diversified logistics network of "overseas warehouses + China-Europe Railway Express" to improve supply chain stability and delivery efficiency [8]. In terms of risk prevention and control, enterprises should establish a big data-driven risk early warning mechanism, launch customized insurance products for cross-border transactions, and enhance industrial resilience against exchange rate fluctuations and market uncertainties. In terms of market expansion, we should deepen cross-border e-commerce cooperation with Belt and Road countries, actively explore emerging markets in Southeast Asia, the Middle East and Latin America, and steadily promote the facilitation of cross-border payment and settlement to further tap global consumption potential.

6.4 Build a Data Security Guarantee System to Consolidate the Bottom Line of Development

At the enterprise level, compact the main responsibility of data security, apply technologies such as privacy computing and blockchain, and strengthen the whole-process protection; at the legal level, improve laws and regulations on data security and personal information protection, increase penalties for illegal acts such as data leakage and abuse, and raise the cost of violations; at the industry level, establish a data security association, formulate circulation standards, and promote self-discipline; at the supervision level, build a national unified e-commerce data security supervision platform to realize dynamic monitoring of the whole life cycle.

6.5 Innovate Industry Standards and Supervision Mechanisms to Improve Governance Efficiency

In terms of standard construction, formulate unified technical, service, and data standards to promote data interconnection between platforms; in terms of format supervision, issue special rules for live-streaming e-commerce and social e-commerce, and clarify the responsibility boundaries of platforms, anchors, and merchants; in terms of supervision mode, build a diversified system of "government supervision + industry self-discipline + social supervision", and use big data and artificial intelligence to realize smart supervision; in terms of complaint handling, unblock channels, establish a rapid response mechanism, and protect consumers' rights and interests.

6.6 Promote Green and Low-Carbon Transformation to Achieve Sustainable Development

From the perspective of green supply-side optimization, e-commerce platforms should actively popularize and apply degradable green packaging materials, set up exclusive ecological commodity exhibition areas, and continuously elevate the supply proportion and market share of green low-carbon products. In the field of logistics carbon emission reduction, it is essential to accelerate the penetration and application of new energy logistics vehicles, adopt intelligent route scheduling and distribution path optimization algorithms, so as to effectively reduce the comprehensive carbon emission intensity of the whole logistics chain

In terms of institutional incentive design, a standardized green e-commerce evaluation and certification

system should be constructed. Targeted fiscal subsidies and preferential tax policies shall be implemented for qualified platform merchants and logistics enterprises to guide their voluntary green transformation development. From the dimension of consumer behavior guidance, multi-channel green consumption publicity and popularization activities should be launched. Meanwhile, a sound waste packaging recycling and reverse recovery system should be established to fully stimulate residents'intrinsic willingness and behavioral tendency of green low-carbon consumption,thereby forming a sustainable development pattern featuring coordinated participation of platforms, enterprises and consumers.

7. Conclusion and Prospect

7.1 Research Conclusion

The integration and synergistic development between the digital economy and e-commerce is grounded in rigorous theoretical foundations and pragmatic imperatives. It is substantiated by four core theories: industrial convergence theory, transaction cost theory, innovation diffusion theory, and data factor theory. The iterative advancement of digital technologies and the large-scale expansion of e-commerce have catalyzed their integration, thereby forging a novel driver of economic growth.

Currently, their integration has yielded notable achievements in technology empowerment, scenario expansion, infrastructure support, cross-border trade, and the transformation of small and medium-sized enterprises (SMEs), emerging as a pivotal force in boosting consumption, stabilizing foreign trade, and revitalizing industries. Nevertheless, it confronts six major bottlenecks: infrastructure imbalance, impeded SME transformation, prominent cross-border risks, data security vulnerabilities, inadequate regulatory adaptation, and lagging green development, which constrain the full release of synergistic effects.

To facilitate high-quality integrated development, systematic measures are required across six dimensions: infrastructure optimization, SME empowerment, cross-border risk mitigation, data security governance, regulatory innovation, and green transformation, with the aim of establishing a comprehensive, multi-level, and three-dimensional developmental system.

7.2 Future Prospect

In the future, the integration and synergy between the digital economy and e-commerce will present five major trends: first, deeper technology integration, where artificial intelligence, metaverse and other technologies promote consumer experience from convenience to immersion; second, wider scenario application, where e-commerce penetrates into industrial supply chains, agricultural production and marketing, remote services and other industries, breaking through supply and demand barriers; third, more synergistic industrial ecology, where platforms become resource sharing hubs, large, medium and small enterprises develop in an integrated manner, and the industrial chain realizes network integration; fourth, green and low-carbon becoming the mainstream, where carbon footprint accounting, green packaging, and circular systems are widely used, and the industry shifts to sustainable development; fifth, deeper international cooperation, where cross-border e-commerce is deeply bound to the Digital Silk

Road, forming a new pattern of global digital trade[3].

Facing new trends and challenges, it is necessary to continuously focus on the core issues in the integration and synergy, strengthen technological innovation, improve institutional supply, optimize the governance system, promote the in-depth coupling and collaborative innovation of the digital economy and e-commerce, and inject sustained impetus into the high-quality development of China's economy.

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