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Digitalization Driving High-Quality Converged Development of Rural Primary, Secondary, and Tertiary Industries: Mechanisms, Effects, and Paths

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Abstract: The convergence of rural primary, secondary, and tertiary industries is an effective way to establish a modern rural industrial system. The digital transformation of rural industries is a new idea to promote high-quality converged development. This paper focuses on the converged development of China's rural industries, trying to explore the impact of digitalization on the high-quality converged development of China's rural industries. Firstly, the mechanisms of digitalization driving rural industrial convergence are revealed. Secondly, we use panel data of 30 provinces (autonomous regions, municipalities) in China from 2011 to 2020 to empirically test the impact of digitalization on rural industrial convergence. Finally, considering the regional differences in industrial structure, the non-linear impact of digitalization on rural industrial convergence is examined. The results indicate digitalization has a significant positive effect on rural industrial convergence, and the impact of the latter has a dual threshold effect with regional heterogeneity based on industrial structure. Therefore, it is suggested to accelerate the construction of digital infrastructure, strengthen digital application, promote regional coordinated development, and improve the institutional system, which are expected to contribute to a deeper connection between digitalization and rural industries.

Keywords: industrial convergence; digitalized industry; high-quality development; rural revitalization; rural China

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1. Introduction

Whether in developed or developing countries, agricultural and rural issues are always important economic issues related to national economic development. High-quality development refers to balanced development between urban and rural areas in the region, innovation as the driving force, and green development. With the flow of production factors such as population, capital, and technology, rural areas have not only the primary industry, but also secondary and tertiary industries. Promoting the high-quality converged development of rural industries is an important issue to promote the high-quality development of the rural economy.

This study focuses on China, currently the second largest agricultural country in the world. According to the bulletin of China's seventh national census, 36.11% of the total population of China lives in the countryside, that is, farmers are a relatively large group compared with other countries. By region, the eastern, central, western, and northeastern regions account for 39.93%, 25.83%, 27.12, and 6.98% of the population, respectively. Sannong (Three Rural Issues), namely "agriculture, rural areas, and farmers", has always been the foundation of China, and solving the Sannong problems has always been the top priority of the Communist Party of China. Since the reform and opening up, China's Sannong work has achieved unprecedented great performance. However, the foundation for high-quality development in agriculture and rural areas is not yet solid, and the development of rural industries is still in its early stage. The distribution of urban–rural resources is uneven, the supply and demand are mismatched, and the space for farmers to increase income is subject to multiple restrictions. Rural revitalization and industrial prosperity are the top priorities. The convergence of rural primary, secondary, and tertiary industries is an effective way to build a modern agricultural industrial system, achieve the prosperity of rural industries, and explore the path of modernization of agriculture with Chinese characteristics. In the strategic critical period of comprehensively promoting rural revitalization, how to further enhance the depth and quality of rural industrial convergence has become a crucial topic at present. However, the role of the traditional driving force to promote rural industrial convergence has gradually become smaller. Exploring new impetus to promote rural industrial convergence is vital for high-quality development of the rural economy. In the era of the digital economy, utilizing digital means to promote the convergence of rural industries should be the essence of the problem [1,2]. The research gap exists between novel applications of digitalization and the mature rural industrial system with traditional tools and methods of production.

Literature Review

In recent years, scholars have conducted many beneficial explorations on the rural industrial convergence and the digital economy, proposing a string of enlightening viewpoints, ideas, and propositions. Regarding the development and impact of industrial convergence in rural areas, Naruto Imura [3] proposed the theory of "six-time industrialization". The "six-time industrialization" referred to the "primary industry × secondary industry × tertiary industry = six-time industry". It emphasizes that any industry in the rural industry chain is indispensable; otherwise, the total effect of the six industries will be zero [4]. Therefore, only by closely relying on agriculture and converging secondary and tertiary industries can rural economic benefits achieve a qualitative leap. Industrial convergence alters the basis of competition by blurring the boundaries between separate industries [5]. Digitalization is an information technology revolution that improves labor productivity through technologies such as information communication and digital processing, thereby transforming the economic development situation [6–11]. Bukht and Heeks [12] conducted a more comprehensive analysis of the connotation of the digital economy by dividing it into three levels. The first level is the core part, which only includes basic IT industries such as software and hardware production and IT information services. The second level is a narrow definition of the digital economy, which not only includes the previous part, but also new business modes such as the platform economy and digital services. The third level is called the digitalized economy, which covers emerging industries such as smart agriculture and e-commerce, and includes all digitalized economic activities. The digital economy encourages the convergence of urban and rural development, but the digital divide exists due to infrastructure, population characteristics, and other aspects [13–15].

In China, many studies indicate that to promote high-quality development of agriculture and rural industries, it is necessary to strengthen scientific and technological innovation and vigorously focus on digital development [16,17]. Chen [18] believes the digital economy can play a synergistic role in technological innovation by rural industrial convergence, promoting the extension of the rural industrial chain, and thus promoting industrial transformation, upgrading, and converged development. Zhu and Zhang [19] concluded that the digital economy has the logical inevitability to promote rural industrial convergence by analyzing existing domestic and foreign practices as well as socioeconomic benefits, but we should work hard to solve the legal defects in China's practice. Jiang [20] theoretically discussed the path and difficulties of promoting agricultural transformation and rural industrial convergence with the digital economy and believed that it is necessary to strengthen pilot and case studies to improve the effectiveness of agricultural digital transformation policies. Rural finance has a significant and positive effect on promoting farmers' participation and the industrial convergence [21]. At the same time, from the perspective of financial digitalization, it can be empirically concluded that the application of digital technology in the financial field can effectively promote the converged development of rural industries, not only providing more convenient financial support for the convergence of three industries, but also promoting technological innovation in rural areas [22]. Digital inclusive finance not only promotes the converged development of local rural industries, but also has significant spatial spillover effects and regional heterogeneity [23,24]. From the perspective of rural–urban continuums, rural digitalization can significantly improve the level of rural industrial convergence, and rural human capital has a threshold effect in its impact process [25,26].

This above research provides important references for the study, but there are still some gaps and defects in existing research. Firstly, the existing literature mostly focuses on examining the impact of rural industrial convergence, while focusing less on the influencing factors and related mechanisms that promote rural industrial convergence [27]. Secondly, there is relatively little literature on the impact of digitalization on rural industrial convergence, and there are still many shortcomings in exploring the mechanism of its effects and empirical research [28]. Some factors have been found to positively affect the rural industrial convergence, such as digital finance and digital infrastructure. Part of the research only focuses on digitalization in rural areas while ignoring the urban–rural linkage effect. Part of the research mainly focuses on the impact of digitalization on rural industrial convergence from perspectives of finance and circulation, with less comprehensive examination of digitalization effects. What is the impact of digitalization on the convergence of primary, secondary, and tertiary industries in rural areas? What is the mechanism? These are two key questions to be solved in the research. The above gaps inspire new approaches. This paper takes digitalization as the key factor affecting rural industrial convergence and focuses on the overall digital development. Taking China as an example and using provincial panel data from 30 provinces (autonomous regions, municipalities), this paper proposes the following objectives: deeply reveal the mechanism and effect of the digital driving rural industrial convergence in China, broaden the perspective of academic research, and provide some theoretical support for promoting rural industrial convergence in a wider range by using digitalization. The relevant recommendations are expected to provide important practical guidance for promoting high-quality converged development of rural industries through digital means and promoting the modernization of agriculture and rural areas.

2. Theoretical Analysis and Research Hypotheses

As shown in Figure 1, digitalization plays an important role in reducing transaction costs, optimizing resource allocation, reducing market information incompleteness, promoting technological innovation, and strengthening the correlation between different industries. The impact of digitalization on the upgrading of traditional industries and the cultivation of emerging industries is obvious. This section reveals the mechanism of digitalization driving converged development of rural primary, secondary, and tertiary industries from three aspects: the extension of the agricultural industry chain, the realization of agricultural multifunctionality, and the converged development of multiple factors based on the functional characteristics of digitalization.

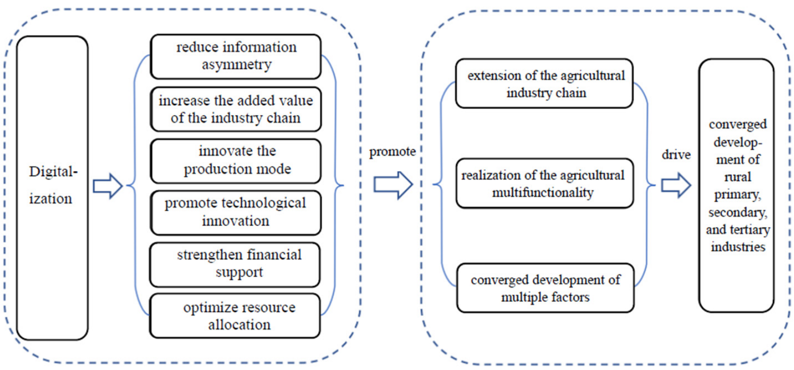

Figure 1. The mechanism of digitalization driving rural industrial convergence.

2.1. The Promoting Effect of Digitalization on the Extension of Agricultural Industry Chain

The entire agricultural industry chain refers to the integration of agricultural R&D, production, processing, circulation, sales, brand, experience, consumption, service, and other links, as well as the close connection, effective connection, coupling, and coordinated development between various entities in the industry chain, forming an organic whole [29]. The extension of the agricultural industry chain plays a crucial role in the policy of rural industrial convergence. Digitalization has jointly promoted the extension of the agricultural industry chain by enhancing the correlation of the entire agricultural industry chain and strengthening the interest connection of agricultural business entities.

2.1.1. Strengthen the Correlation of the Entire Agricultural Industry Chain

In terms of production and processing, the application of the Internet of Things (IoT) and the Internet in agriculture has made information exchange between primary agricultural producers and agricultural product processing enterprises more convenient [30]. Agricultural producers can have two-way communication and trade exchanges with processing manufacturers through various digital transaction service platforms established by government or enterprises. At the same time, both parties can also use the agricultural big data platform to instantly query and obtain various product transaction data, so as to reduce information asymmetry, reduce the transaction costs of both, and promote the vertical extension of the industry chain. Big data and digital technology can also capture market trends in a timely manner and grasp the actual demands of consumers, enabling agricultural and sideline product suppliers to adjust market strategies and supply structures in a timely manner, reduce overproduction caused by obstructed supply and sales, increase the supply of agricultural products that meet market demand and consumer preference, strengthen the connection between production and consumption, and promote the sustainable development of the agricultural product processing industry.

In terms of supply and demand connection, the digitalization and intelligentization of the agricultural product processing industry have enhanced the standardization and branding of products, adding more high-end consumption functions to traditional agricultural products. This not only significantly increases the added value of agricultural products, enhancing the value chain, but also makes the supply of agricultural products more able to meet high standards and demands of current consumers. Nowadays, digital and refined production management models such as full-process quality control platforms, intelligent assembly lines, and smart agricultural factories enable enterprises to achieve quality control and standardization of agricultural products without spending much, and also encourage more enterprises to participate in the precision processing of agricultural products. Not only has it enhanced the processing and transformation capabilities of enterprises for agricultural products, but it has also improved the quality, enriched types, and optimized the supply structure of agricultural products. At the same time, the agricultural product quality traceability platform achieves multi-party supervision of agricultural product quality by the government and society, enhances consumers' trust in agricultural products' quality, and narrows the distance between production and consumption. That makes the production and sales cycle mechanism smoother, and the connection between supply and demand closer.

In terms of storage, transportation, and circulation, the digitization of logistics has played an important role in the smooth transaction of various links of agricultural and sideline products. The construction of a digital circulation information platform makes the search, transportation, return, and exchange processes of agricultural products no longer cumbersome. Various entities involved in agricultural product trading can conduct long-distance transactions with low cost, making the connections between agricultural product producers, processors, and consumers connected more closely. The real-time tracking platform for logistics information also enables trading parties to quickly and conveniently grasp the logistics dynamics of goods, saving much time. In the process of agricultural product storage and circulation, real-time digital monitoring and control of environmental factors such as temperature and humidity around agricultural products significantly reduces the loss of agricultural products during logistics transportation. It also reduces unit product costs and transaction costs, expands profit margins, and improves market efficiency.

In summary, digitalization has greatly enhanced the correlation between various links in the agricultural industry chain, such as R&D, production, processing, circulation, and consumption, by strengthening information connectivity, reducing transaction costs, and promoting technological innovation. It has made the upstream, midstream, and downstream connections of the industry chain closer, making the agricultural product supply chain smoother, and thus promoting the converged development of rural industries.

2.1.2. Strengthen the Interest Connection between Agricultural Operation Entities

Firstly, digitalization helps to improve the management level of new agricultural operation entities. On the one hand, digitalization can significantly reduce the cost of information acquisition, enhance the timeliness and accuracy of operation entities' access to market information, and thus reduce information asymmetry. Big data analysis of products, prices, and markets can also quickly and accurately assess the operational status of oneself and even the entire industry, thereby formulating the optimal management strategy and reducing decision-making costs of operation entities. On the other hand, the new technologies and knowledge brought about by digitalization can cultivate more professional talents for agricultural management. By learning advanced technologies and management theories, the level of rural human capital can be improved, further enhancing the modern operation and management capabilities of new agricultural operation entities and reducing the management costs of operation entities by improving organizational structures and operating systems [31]. Furthermore, digitalization can also improve the ability of agricultural operation entities to cope with risks and adapt to various environmental changes.

Secondly, digitization can promote the transformation of traditional agricultural operation entities into new ones. With the continuous innovation of digital and agricultural technology, the traditional agricultural business model of blindly "burying oneself in hard work" is no longer able to adapt to the rapidly growing social demands. The optimized allocation of factor resources by digitalization continuously drives the traditional agricultural operation entities to transform from small-scale, extensive, inefficient, and low-income modes to new modes of scale, intensification, refinement, specialization, and efficiency. And the latter promotes its active integration into market competition, continuously extending to the middle and downstream links of the industry chain.

Thirdly, digitalization can enhance information connectivity among various business entities, promote interest connections, and optimize the interest chain. In the past, information asymmetry and high transaction costs were obstacles to connecting the agricultural industry chain. Digitalization promotes the sharing of information and collaborative cooperation among operation entities, promotes deep convergence and interest correlation among various operation entities, forms a benign communication and transaction mechanism, makes the benefit-sharing mechanism between order-based agricultural, service-driven, cooperative, and other operation entities more stable and reliable, and enhances the resilience of the industry, supply, and interest chain.

Finally, digitalization can further promote the agglomeration of agricultural operation entities in various forms and deepen agricultural industrial clusters. When the convergence of rural industries reaches a certain stage, many new agricultural operators in the industry chain gather within the county spatial scope to form industrial clusters. However, due to factors such as labor, capital, land, and policies, the development space of traditional industrial clusters has become increasingly narrow. Digitalization can break the constraints imposed on operation entities in spatial agglomeration and allocate resources without time and space constraints as much as possible. It can achieve information collection and analysis, production scheduling and coordination at a lower cost, and higher efficiency and accuracy in a larger area and in a shorter period of time. It can also enhance the collaboration among entities in the industry chain, strengthen interest connections between operation entities, deepen agricultural industrial clusters, and boost the converged development of rural industries.

2.2. The Expanding Effect of Digitalization on the Multifunctional Utilization of Agriculture

Expanding the multiple functions of agriculture and promoting the convergence of new modes and industries based on agriculture, in order to provide consumers with more diverse agricultural products and services, is the key to the convergence of rural primary, secondary, and tertiary industries. Digitalization can not only provide services for the multiple functions of agriculture in multiple aspects, but the integration of digital technology and traditional agriculture can also promote the innovative development of new forms and deepen the convergence of rural industries.

2.2.1. Promote the Full Play of Agricultural Economic Functions

The digital development has brought new opportunities to traditional agricultural production modes. By deeply converging digital technology with the agricultural industry, it can not only accurately control the quality of agricultural products, effectively promote the growth of production efficiency, and achieve sustainable development of agriculture, but also promote the formation and development of new agricultural forms such as facility agriculture, smart agriculture, and precision agriculture, enhance the economic function of agriculture, and promote the convergence of rural industries.

Agriculture has long been deeply affected by natural conditions. The development and popularization of informatization and digitalization further encourage agriculture to reduce its dependence on the natural environment and help people make use of the law and improve labor productivity [32]. Under the cooperation of digital technology, accurate prediction of natural condition changes, real-time monitoring of crop growth environment, accurate analysis of agricultural production data, and so on are more conducive to the optimal allocation of resources, the realization of agricultural large-scale production, and the expansion of production possibilities. Smart agriculture is a new digital agriculture mode created by the deep integration of advanced digital factors and traditional agriculture. It adopts intelligent agricultural control, digital agricultural infrastructure, and agricultural IoTs, which can connect many pieces of agricultural machinery and equipment together with various sensor monitoring equipment such as soil, weather, and temperature control into the digital agricultural system. It can realize the regulation of the agricultural production environment and the standard and accurate execution of the entire production process. Under the severe situation of the aging population and decreasing population for agricultural employment, intelligent and digital agricultural production can not only reduce manpower, alleviating the shortage of the rural labor force to a certain extent, but also promote the standardization of agricultural production and the converged development of production, processing, and sales of agricultural products, so as to improve the efficiency of comprehensive agricultural management. It will raise the level of modern agricultural technology and promote the convergence of rural industries.

2.2.2. Assist in the Realization of Agricultural Ecological Functions

Digital technology is embedded in various aspects of agricultural production, enhancing the economic function of agriculture while further strengthening its ecological function. Digital monitoring and control, analysis, and decision making can accurately grasp the growth status of crops and livestock, analyze the soil type and texture and the content and composition of minerals in the water source, and so on, so as to accurately calculate the type and amount of pesticides, fertilizers, and feedstuffs required in production, avoid excessive investment, reduce the pollution of chemical products in soil, air, and water sources, and make agricultural products more green and healthy. Furthermore, digital technology can also integrate knowledge from multiple disciplines such as agriculture, biology, and chemical engineering to carry out research and development of new agricultural technologies, promote the development and progress of resource-saving and green-circular agricultural technology, and promote the transformation from low-energy and low-efficiency traditional chemical agriculture to green, environmentally friendly, and sustainable modern biological agriculture. In addition, the dissemination and popularization of new ideas, knowledge, and technologies brought about by digitalization can also strengthen farmers' ecological and environmental awareness and help them master correct agricultural knowledge and efficient agricultural technology, thereby avoiding blind production inputs and incorrect production operations and making agricultural production more green, efficient, and ecologically harmonious. It can be seen that digitalization is conducive to promoting the transformation of agricultural production modes, promoting green and sustainable development of agricultural ecology, and providing a new development model for the convergence of rural industries.

2.2.3. Promote the Full Play of Agricultural Cultural Functions

Leisure agriculture and rural tourism are the key points of the converged development of rural industries. The development and innovation of digital technology have further pushed the industry to break through, promoted resource allocation, and innovated marketing modes, bringing the development of leisure agriculture and rural tourism to a new level.

Firstly, the Internet and digital platforms provide rich and diverse communication channels and trading platforms for the new forms of leisure agriculture. Operators can promote the unique scenery and agricultural products in rural areas to as many audiences as possible through digital platforms. The big data analysis behind the platform can also accurately target the audience who is most likely to participate in consumption, greatly improving communication efficiency and publicity benefit. The diversification of digital platform functions can also enable operators to directly display and link relevant sales information and promotional activities on promotional content, enabling interested consumers to conveniently and quickly purchase agricultural products or tourism services. The trading platform will provide transaction protection for both operators and consumers, which not only broadens the sales channels of rural tourism services, but also enhances effective communication between two sides, making trading behavior safer and more convenient, significantly reducing transaction costs.

Secondly, digitalization enhances the freshness and sense of experience of rural tourism service, making it more attractive to consumers. The traditional leisure agriculture mode often involves activities such as tasting farm dishes and doing farm work. With the diversification of people's demands, the development of this mode has become somewhat sluggish. Nowadays, leisure agriculture and rural tourism are not only about experiencing agricultural life, but also, new modes such as healthcare, creative agriculture, and leisure tourism are increasingly favored by consumers. This cannot be achieved without the integration of digital and intelligent services such as one-stop service ports for leisure agriculture, enabling rural tourism to integrate with other modern services in cities, providing tourists with better travel experiences and making rural tourism more unique and attractive.

Finally, digitalization enhances the management capabilities of new operation entities in leisure agriculture. Unlike the traditional family workshop organizational form of the rural farmhouse, the digital operation system can innovate management modes, effectively balance agriculture and service industries, strengthen the integration of the two, significantly improve the efficiency of modern management, and promote the organic integration between rural tourism and modern agricultural production. Digitalization can also improve the marketization level of operation entities, help them understand changes in market supply and demand in a timely manner, enhance the effectiveness and scientificity of marketing strategies, and enhance the market competitiveness of operation entities.

In summary, digitalization can assist in the development of core forms of leisure agriculture, thereby expanding cultural functions of agriculture, expanding value-added space, strengthening the convergence and mutual progress of agriculture and cultural tourism industries, and driving the converged development of rural industries.

2.3. The Optimization Effect of Digitalization on the Converged Development of Multiple Factors

Digitalization has a strong ability to allocate production factors and can break through regional limitations to enhance cross-border flow and integration of resources. Therefore, digitalization can promote the effective integration of factors and drive high-quality converged development of rural industries.

2.3.1. Increase Support for Agriculture-Related Finance

Previous studies have shown that the convergence of rural industries and modern finance is an important aspect of rural industry convergence [33–35]. At the same time, the support of finance as an important source of capital for the development of rural industries is also crucial for the success of the deep convergence of rural industries. Capital constraints are an obstacle to further deepening the convergence of rural industries, making new operation entities more willing but less able to actively promote convergence. Nowadays, the digitally inclusive finance formed by the combination of digitalization and financial services has to some extent changed this dilemma, promoted the coordinated development of finance in rural areas, alleviated the financial constraints faced by the convergence of rural industries, and effectively improved the inclusiveness of financial services.

Firstly, digital finance can effectively reduce information asymmetry and improve the credit system by utilizing digital technology. Under traditional financial modes, there are mainly mortgage loans, farmers' joint guarantee loans, and land management rights mortgage financing and other financial support modes. However, due to the scarcity of movable or immovable property of agricultural operation entities, the imperfect land management rights mortgage system, and the relative lag in the construction of credit systems in rural areas, many financial institutions choose to reduce loan quotas and reduce agricultural loans for their own interests in order to avoid risks. Therefore, the financial availability of agricultural operation entities is relatively low, especially for small farmers with fewer properties available for collateral and incomplete credit records. But digitally inclusive finance can use digital technology to accurately capture and effectively integrate massive information of various operation entities and then use big data analysis to evaluate their true debt-bearing capacity and credit guarantee ability, effectively reducing information asymmetry between financial institutions and customers, reducing risk control costs, enhancing social trust, and improving credit systems. Financial institutions can not only effectively control risks, but also improve the financial availability and financing efficiency of agricultural operation entities. At the same time, digitalization can also help financial institutions accurately capture target users through big data, reduce credit market friction, lower financing thresholds, save search costs for financing between both parties, improve the scale, speed, and accuracy of rural financial credit, and provide more financial support for the converged development of rural industries.

Secondly, digital finance combines the advantages of digital technology to promote capital flow and promote urban capital to the countryside. For a long time, the existence of the urban–rural dual economic structure has formed a barrier to the flow of resources. With the profit-driven nature of financial capital, a large amount of funds has gathered in urban areas, while in rural areas, funds are scarce and investment is sluggish. Digitalization has unique advantages of large-scale, cross-regional, low-cost, and efficient resource allocation. Therefore, digitally inclusive finance can strengthen the liquidity of capital between urban and rural areas, absorb more idle funds in the financial market, encourage and attract more funds to invest in new operation entities and rural industries, and promote the converged development of rural industries. In addition, digital finance can also achieve precise and efficient allocation of capital through information advantages, enabling limited financial resources to achieve optimal allocation and maximum efficiency between urban and rural areas, different industries, and various operation entities, fully supporting the converged development of rural industries.

Thirdly, the competition brought about by the popularity of digital finance has prompted traditional financial institutions to strengthen their support for rural credit. Compared to the traditional financial system, digitally inclusive finance brings convenient online completion of digital financial services, and the process of financial services is simplified and accuracy is improved. The financing time and cost are significantly reduced, and financing efficiency is constantly improving. So more and more operation entities are inclined to choose digital financial services. This has brought pressure to traditional financial institutions, which enhances their organizational vitality and innovation activity due to the "catfish effect", actively participates in market competition in rural areas, lowers customer thresholds, increases the scope and strength of financial services in rural areas, enhances the availability of capital in rural areas, further expands the breadth and depth of rural finance, and deepens the convergence of rural industries.

2.3.2. Enhance the Innovation Capability of the Agricultural Industry

Technological innovation is the prerequisite and internal driving force for the convergence of rural industries, which can effectively break down barriers between primary, secondary, and tertiary industries and promote inter-industry convergence and innovation or different sectors within industries. Digitalization has an indelible and important impact on promoting technological innovation. It can strengthen the role of technological factors in agricultural development, improve the innovation ability of the agricultural industry, and effectively allocate various factor resources, promoting further deepening of the convergence of rural industries.

On the one hand, digitalization has a direct driving effect on the technological progress of the agricultural industry. Digital technology has high permeability and integration and can be quickly and effectively applied in various sectors and circumstances. It creates a large number of technological demands in a large number of practical applications, driving technological innovation through those demands. Digital technology and digital data and knowledge also have strong positive externality. Through technology and knowledge spillovers, it can improve the technology and knowledge level of many industries and adjacent regions, optimize the science and technology innovation ecology, and thus promote whole-industrial and multi-directional technological progress. Digitalization is also conducive to strengthening technological exchanges between different regions and fields, promoting the continuous exchange and integration of various factors and resources such as technology, capital, and talent, thereby promoting industrial innovation and driving the converged development of rural industries.

On the other hand, digitalization can further promote the improvement of agricultural industry innovation capabilities through indirect impacts. Technological innovation cannot be separated from high-quality human resources, and digitalization can promote technological progress by mobilizing human resource factors. Firstly, digitalization can effectively enhance the overall level of rural human capital. Digitalization has inherent advantages in the dissemination of knowledge and technology, enabling low-cost and efficient information transmission. The gradual completion of digital infrastructure construction enables residents in rural areas to easily access a vast amount of digital resources for learning and training through various digital platforms, just like urban residents [36,37]. This enables continuous improvement of cultural literacy and skill quality, promoting continuous innovation in scientific knowledge and technology. Secondly, digitalization can also promote more professional talents to penetrate into rural grassroots and invest in agricultural industry technology R&D. Under the traditional agricultural production mode, many young people with professional knowledge are unwilling to stay in rural areas for agricultural production and development due to low agricultural economic benefits and hard work. However, the high-tech and high-efficiency characteristics of digital agricultural production and modern agricultural management have to some extent attracted high-quality talents to gather in rural areas, dedicated to modern agricultural production and technology R&D. That provides an inexhaustible driving force for high-quality convergence of rural industries.

In summary, Hypothesis 1 is proposed as follows: Digitalization has a positive promoting effect on the convergence of rural primary, secondary, and tertiary industries.

Given China's national conditions, the impact of digitalization on rural industrial convergence may vary due to regional characteristics. Considering that industrial structure is an important economic environment factor, the differences in industrial structure in different regions may be an important reason for the regional heterogeneity of the effect of digitalization on rural industrial convergence. In areas where the development of the secondary and tertiary industries is relatively weak, the foundation of digital development is average, and the level of digital development may be relatively backward; thus, the impact of digitalization on rural industrial convergence may be weak. In areas with higher levels of development in the secondary and tertiary industries, the industrial foundation for digital development is relatively good, so the level of digitalization may be relatively high [23]. The effectiveness of using digitalization to drive the convergence of rural primary, secondary, and tertiary industries may be better. Therefore, Hypothesis 2 is further proposed as follows: There are differences in the impact of digitalization on the convergence of rural primary, secondary, and tertiary industries under different industrial structures. That is, there exists a threshold effect based on industrial structure.

3. Research Design

3.1. Research Area

The empirical analysis of this paper focuses on rural China, trying to make an exploratory study in the field of industrial economics and rural economics.

There are 34 provincial administrative regions in China, including 23 provinces, 5 autonomous regions, 4 municipalities directly under the Central Government, and 2 special administrative regions. Due to the serious lack of data in Tibet, Hong Kong SAR, Macao SAR, and Taiwan, they are not included here in our study. We use panel data from 30 other provinces (autonomous regions, municipalities) of China.

3.2. Modelling

3.2.1. Two-Way Fixed Effect Model

This paper uses a two-way fixed effect model to examine the impact and heterogeneity of digitalization on the converged development of rural industries. The formula for modeling is as follows:

$$RIC_{it} = \alpha_{it} + \beta Dig_{it} + \gamma X_{it} + \delta_i + \varphi_t + \varepsilon_{it} \tag{1}$$

where RIC_{it} refers to the level of rural industrial convergence of Province i in Year t, Dig_{it} refers to the level of digitalization of Province i in Year t, X refers to the relevant control variables, δ_i is the individual fixed effect, φ_t is the time fixed effect, and ε_{it} is the error term.

3.2.2. Panel Threshold Effect Model

This paper draws inspiration from the research methods of Hansen (2002) on the panel threshold model and constructs the following model formula for different threshold quantities.

We take a single threshold as an example:

$$RIC_{it} = \alpha_{it} + \beta_1 Dig_{it} \times I(IS_{it} \leq \theta) + \beta_2 Dig_{it} \times I(IS_{it} \geq \theta) + \gamma X_{it} + \delta_i + \varepsilon_{it} \tag{2}$$

where IS_{it} is a threshold variable. It represents the industrial structure of Province i in Year t. θ is the threshold value, and $I(.)$ is an indicator function.

3.3. Variable Selection

3.3.1. The Explained Variable

The level of convergence of primary, secondary, and tertiary industries in rural areas (RIC) is the explained variable. This variable is obtained by constructing an evaluation system and using the entropy method to measure, and to some extent it represents an indicator of the degree of convergence of rural primary, secondary, and tertiary industries in a region. There are two main forms of evaluation systems for measuring the convergence level of rural primary, secondary, and tertiary industries in existing research. Firstly, starting from practical content, indicators are selected from the evaluation dimensions of agricultural industry chain extension, agricultural multifunctionality, the converged development of agriculture and the service industry, and the cultivation of new agricultural forms, such as explored by Zhang and Wen [24]. The second is to construct an evaluation system from two aspects: convergence behavior and convergence results. Convergence behavior refers to the practical content of rural industrial convergence mentioned above, and the convergence results refer to economic and social benefits brought by rural industrial convergence.

Based on the principles of scientificity, representativeness, and operability, and in accordance with The Guiding Opinions of the General Office of the State Council of China on Promoting the Converged Development of Rural Primary, Secondary, and Tertiary Industries, as well as the "The 14th Five-Year Plan of China" to Promote Agricultural and Rural Modernization, this paper establishes an evaluation index system based on the research methods of the authoritative literature mentioned above and considering the availability of provincial data, as shown in Table 1.

Table 1. Evaluation index system for the convergence level of rural primary, secondary, and tertiary industries.

Target	Criterion	Indicator	Measurement Methods	Indicator Attribute
Converged level of rural primary, secondary, and tertiary industries	Extension of agricultural industry chain	B1 Proportion of agricultural product processing industry (%)	Annual main business income of agricultural product processing industry/total output value of primary industry	Positive
		B2 Number of farmers' cooperatives per 10,000 people (households)	The total number of registered farmers' cooperatives in the administration of industry and commerce/total rural population	Positive
	Utilizing the multifunctionality of agriculture	B3 Proportion of leisure agriculture (%)	Annual business income of leisure agriculture/total output value of the primary industry	Positive
		B4 Application intensity of fertilizer and pesticide film (tons/hectare)	Total amount of pesticide, fertilizer, and film application/cultivated acreage	Negative
		B5 Per capita output of main agricultural products (kg/person)	Total output of main agricultural products/total population	Positive
		B6 Agriculture level of facility (%)	Total area of facility agriculture/cultivated acreage	Positive
	Converged development of factors	B7 Proportion of agriculture, forestry, animal husbandry, fishing, and service industry (%)	Total output value of agriculture, forestry, animal husbandry and fishery service industry/total output value of agriculture, forestry, animal husbandry and fishery	Positive
		B8 Agricultural loans (100 million yuan)	Amount of local and foreign currency agricultural loans from financial institutions in various regions	Positive

The specific steps of the entropy method are as follows.

Firstly, indicator selection: Assuming there are h years, n samples, and m indicators, X_{ij} is the value of the indicator j in sample i of year λ.

Secondly, standardization:

$$\text{Positive indicators}: X'_{\lambda ij} = \left(X_{\lambda ij} - X_{min}\right)/\left(X_{max} - X_{min}\right) \tag{3}$$

$$\text{Negative indicator}: X'_{\lambda ij} = \left(X_{max} - X_{\lambda ij}\right)/\left(X_{max} - X_{min}\right) \tag{4}$$

Among them, $i = 1, 2, 3, \ldots, n$; $j = 1, 2, 3, \ldots, m$; X_{max} represents the maximum value of the indicator; X_{min} represents the minimum value of the indicator.

Thirdly, calculate the proportion of indicators $P_{\lambda ij}$:

$$P_{\lambda ij} = \frac{X'_{\lambda ij}}{\sum_{\lambda=1}^{h} \sum_{i=1}^{n} X'_{\lambda ij}} \tag{5}$$

$P_{\lambda ij}$ represents the proportion of the indicator j in sample i of year λ.

Fourthly, calculate the entropy values of various indicators:

$$E_j = -k\sum_{\lambda=1}^{h} \sum_{i=1}^{n} P_{\lambda ij} lnP_{\lambda ij},\ k = 1/ln(hn) \tag{6}$$

Fifth, calculate the coefficient of difference for each indicator:

$$D_j = 1 - E_j \tag{7}$$

Sixth, calculate the weights of various indicators:

$$W_j = D_j/\sum_{j=1}^{m} D_j \tag{8}$$

Seventh, calculate the composite index; use the previously calculated weights W_j compared to standardized indicator values $X'_{\lambda ij}$ using the weighted average method to obtain the comprehensive index of digitalization level $Dig_{\lambda i}$ of province i in year λ.

$$Dig_{\lambda i} = \sum_{j=1}^{m} \left(W_j \cdot X'_{\lambda ij}\right) \tag{9}$$

3.3.2. The Core Explanatory Variable

Digitalization level (Dig). This variable is obtained by constructing an evaluation index system and using the entropy method to measure it, and to some extent represents an indicator of the level of digital development in a region. This paper refers to the main indicators of the "The 14th Five-Year Plan of China" for the Development of Digital Economy, as well as authoritative literature from experts and scholars [18–20,38]. Based on the availability of indicator data, an evaluation index system for this paper is established from the two criteria of digital infrastructure level and digital application level, as shown in Table 2.

3.3.3. Threshold Variables

Industrial Structure (IS). The industrial structure can to some extent reflect the economic development stage of a region and is an important component of the socio-economic system. In the process of economic and social development, the industrial structure will meet significant changes, mainly reflected in the transfer of labor-intensive industries to capital-intensive and knowledge technology-intensive industries with the development of productivity. This process is also known as the upgrading of industrial structure. The differences in regional economic environments caused by different industrial structures may also lead to differences in the impact of digitalization on the convergence of rural primary, secondary, and tertiary industries. This paper draws inspiration from the approach of

Zhang and Wen [24] and uses the Petty Clark Theorem to select the ratio of the total added value of the secondary and tertiary industries to the regional GDP to measure the degree of industrial structure upgrading to characterize the industrial structure of each region.

Table 2. Digitalization level evaluation indicator system.

Target	Criterion	Indicator	Measurement Methods	Unit	Indicator Attribute
Digitalization level	Digital infrastructure level	X1 Internet penetration rate	Internet broadband access users/provincial resident population	%	Positive
		X2 Mobile phone penetration rate	Number of mobile phones per 100 people	Per 100 people	Positive
		X3 Internet broadband access ports per capita	Number of internet broadband access ports/provincial resident population	Per person	Positive
		X4 Optical cable density	Optical cable line length/provincial area	km/10,000 km^2	Positive
	Digital application level	X5 Investment in information transmission, software, and Information Technology Services	Total investment in information transmission, software, and information technology services by region	100 mn yuan	Positive
		X6 Proportion of digital practitioners	Information transmission, software, and information technology services: urban practitioners/urban practitioners	%	Positive
		X7 Software business income	Software business revenue by region	100 mn yuan	Positive
		X8 Telecom business volume per capita	Total telecom business volume per province/permanent resident population	100 mn yuan/10,000 people	Positive
		X9 Development level of digital inclusive finance	Peking University China—Digital Inclusive Finance Index	--	Positive
		X10 E-commerce Sales	E-commerce sales by region	100 mn yuan	Positive

3.3.4. Control Variables

This paper selects (1) local financial support (FIS) as a representation of agricultural, forestry, and water expenditures in local financial expenditures. (2) Transport infrastructure (TIN) is measured by the density of roads by region. (3) Industrial Structure (IS) is measured by the ratio of the total added value of the secondary and tertiary industries to the regional GDP. (4) Rural fixed assets investment (RF) is represented by the amount of rural fixed assets investment. (5) The level of express development (EXP) is measured by the express delivery volume by region. (6) The level of economic development (PGDP) is measured by GDP per capita. (7) The level of technological progress (DIP) is characterized by the acceptance of domestic invention patent applications. (8) The level of rural human capital (RHC) is characterized by the education years per capita of rural residents by region. The calculation formula is as follows: education years per capita of rural residents = 0 × The proportion of illiterate and semi-illiterate population + 6 × Proportion of primary school educated population + 9 × Proportion of middle school educated population + 12 × Proportion of high school educated population + 17 × The proportion of people with college education or above.

3.4. Variable Selection

We use panel data of 30 provinces (autonomous regions, municipalities) in China from 2011 to 2020. The data sources of the digital indicator system are China Statistical Yearbook, China Statistical Yearbook of the Tertiary Industry, and statistical yearbooks of various provinces and cities, as well as Peking University's China Digital Inclusive Finance

Index [39]. The data sources of the rural industry convergence indicator system are as follows. The annual main business income data of the agricultural product processing industry are sourced from Yearbook of China Agricultural Products Processing Industries and statistical yearbooks of various provinces and cities. The data of farmers' cooperatives are sourced from Yearbook of Industry and Commerce Administration of China, statistical yearbooks of various provinces and cities, and the market entity development report on the official website of the Administration for Market Regulation of various provinces and cities. The data of leisure agriculture are sourced from Yearbook of Leisure Agriculture of China and statistical yearbooks of various provinces and cities. Facility agriculture data are sourced from the National Greenhouse Data System and relevant bulletins on the official websites of various provinces and cities. Agricultural loan data are sourced from Almanac of China's Finance and Banking and Wind Financial Terminal Database, while other indicators' data are sourced from China Statistical Yearbook, China Rural Statistical Yearbook, and statistical yearbooks of various provinces and cities. The data sources for threshold variables and control variables are both from the National Bureau of Statistics.

Shown in Table 3 are descriptive statistics for all variables.

Table 3. Descriptive statistics for all variables.

Variables	Obs	Mean	Std. Dev.	Min	Max
RIC	300	0.218	0.100	0.060	0.619
Dig	300	0.177	0.139	0.012	0.796
RIC_1	300	0.032	0.035	0.000	0.224
RIC_2	300	0.126	0.076	0.022	0.423
RIC_3	300	0.060	0.028	0.007	0.139
Dig_1	300	0.076	0.047	0.007	0.281
Dig_2	300	0.101	0.098	0.005	0.627
FIS	300	546.85	270.37	91.78	1339.36
TIN	300	0.945	0.504	0.089	2.194
IS	300	0.843	0.083	0.543	0.993
EXP	300	10.735	25.176	0.024	220.818
RF	300	326.53	231.68	2.10	966.70
RHC	300	7.789	0.606	5.878	9.801
PGDP	300	53,837	27,036	16,024	164,158
DIP	300	32,452	42,813	204	216,469

4. Empirical Results and Analysis

4.1. Benchmark Regression Results

In order to verify Hypothesis 1, the regression results obtained using the FE model are shown in Table 4. Model (1) and Model (3) are the regression estimates of the two-way FE model, while Model (2) and Model (4) are the estimated results of the random effects (RE) model as a control.

Firstly, overall, from the empirical results of Model (1) to Model (4), it can be found that the impact of digitalization on the convergence of rural primary, secondary, and tertiary industries is significant at the 1% level and has a positive coefficient, indicating that digitalization can indeed promote the development of rural industrial convergence. Secondly, specifically, according to the two-way FE model <Model (1)>, when no control variables have been included, the result obtained is that digitalization can significantly promote rural industrial convergence, with a significance level of 1%. After adding numerous control variables to Model (3), the regression coefficient of digitalization is still significant at the 1% level, with a coefficient value of 0.4521. This indicates that for every unit increase in digitalization level, the convergence level of rural primary, secondary, and tertiary industries increases by 0.4521 units. In addition, the goodness of fit of the model in the observation table shows that the goodness of fit of Model (1) and Model (3) is 64.3% and 71.4%, respectively. It can be seen that the model has a good degree of fit and the reliability of regression results is high. Combining the results of RE models <Model (2) and (4)>, it can be seen that in Model (2), the regression coefficient of digitalization on rural industrial convergence is 0.3523, which is significant at the 1% level. In Model (4), the regression coefficient of digitalization on rural industrial convergence is also significant at the 1% level. Therefore, compared with the regression results of the two models, the results of digitalization promoting rural industrial convergence are relatively stable. In summary, Hypothesis 1 of this article is valid through verification.

Table 4. Benchmark regression results.

Variables	**(1)** **RIC** [1]	**(2)** **RIC**	**(3)** **RIC**	**(4)** **RIC**
Dig	0.3700 ***	0.3523 ***	0.4521 ***	0.3684 ***
	(2.92)	(19.22)	(3.78)	(7.50)
FIS			−0.0722 **	−0.0237 **
			(−2.26)	(−1.98)
TIN			−0.0325	−0.0165
			(−0.44)	(−1.11)
IS			0.3354 **	0.3858 ***
			(2.44)	(4.84)
EXP			−0.0005 ***	−0.0005 ***
			(−3.35)	(−3.81)
RF			−0.0253	−0.0093
			(−1.51)	(−1.38)
RHC			0.0129	0.0644
			(0.15)	(0.94)
PGDP			−0.0068	−0.0091
			(−0.11)	(−0.40)
DIP			0.0092	0.0256 ***
			(0.77)	(4.19)
Constant	0.1379 ***	0.1555 ***	0.2139	−0.2553
	(11.13)	(10.40)	(0.36)	(−1.17)
Observations	300	300	300	300
R-squared	0.643	0.571	0.714	0.655
Province	Yes	No	Yes	No
Year	Yes	No	Yes	No

[1] *z*-statistics or *t*-statistics in parentheses, *** $p < 0.01$, ** $p < 0.05$.

4.2. Threshold Effect Regression Results

4.2.1. Test for the Existence of Threshold Effect

Before conducting threshold effect regression analysis, it is necessary to first determine the specific form of the model, that is, to test the existence of threshold effects and the corresponding number of thresholds. According to Hansen's test, this article uses the Bootstrap method to repeatedly sample 1000 times and obtains the threshold effect test results as shown in Table 5. According to the F-value and *p*-value corresponding to the number of different thresholds in the table, it can be seen that both single and dual thresholds passed the test at a significance level of 1%, while the *p*-value of the triple threshold reached 0.4460, which did not pass the significance test. Therefore, the panel threshold effect test results indicate that there is indeed a threshold effect based on industrial structure in the impact of digitalization on rural industrial convergence, and it is a dual threshold.

Table 5. Threshold effect test results.

Threshold Variable	**Number of Thresholds**	**Bootstrap Frequency**	***F*-Value**	***p*-Value**	**Critical Value**		
					10%	**5%**	**1%**
Industrial Structure (IS)	Single threshold	1000	85.18	0.0000	28.6038	34.8034	45.9468
	Dual threshold	1000	42.15	0.0070	24.2714	28.6836	39.8524
	Triple threshold	1000	20.82	0.4460	44.9642	54.2116	67.2229

4.2.2. Threshold Estimate Values and Confidence Intervals

After confirming the threshold effect of digitalization on rural industrial convergence, the specific threshold values are further estimated, and the estimated results obtained through measurement are shown in Table 6 and Figure 2. The data results indicate that the dual threshold estimate values of industrial structure are 0.8629 and 0.9027, both within their respective 95% confidence intervals. This indicates that the threshold estimates are consistent with the true values, and the obtained results are credible.

Table 6. Threshold estimate values and confidence intervals.

	Threshold Estimate Value	95% Confidence Interval
First threshold	0.8629	[0.8562, 0.8639]
Second threshold	0.9027	[0.8992, 0.9062]

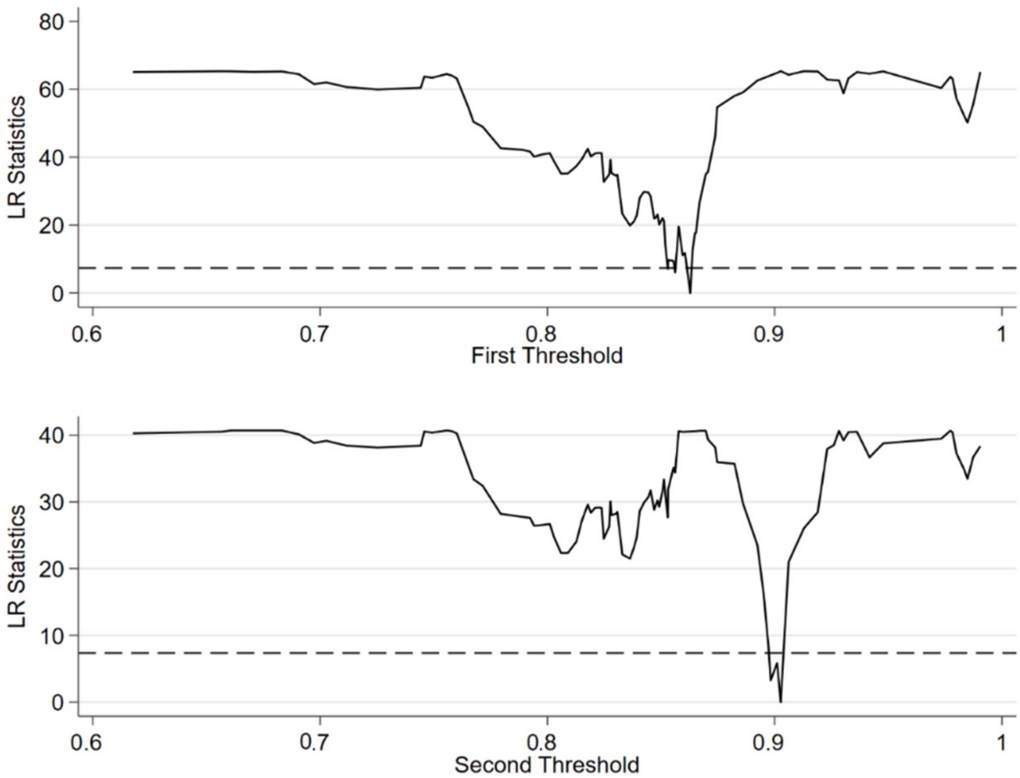

Figure 2. Threshold effect results. If the curve has parts below the dashed line, it indicates that the regression has passed the confidence interval test.

4.2.3. Analysis of Threshold Regression Results

The parameter estimation results of the panel threshold model are further obtained in Table 7. It can be seen that when the degree of industrial structure upgrading is less than 0.8629, the regression coefficient of digitalization is not significant, indicating that when the threshold variable is lower than the first threshold value, the phased impact of digitalization on rural industrial convergence is not significant in the first stage, making it difficult to promote rural industrial convergence. When the degree of industrial structure upgrading is greater than or equal to 0.8629 but less than or equal to 0.9027, the regression coefficient of digitalization is significantly positive at the 1% level, with a coefficient of 0.1728. This means that when the degree of industrial structure upgrading is between the first and second thresholds, digitalization can have a positive promoting effect on the converged development of rural industries. That is, when the digitalization level increases by one unit, the level of rural industrial convergence increases by 0.1728 units. When the degree of industrial structure upgrading is greater than 0.9027, the regression coefficient of digitalization increases to 0.3699 and still maintains significance at the 1% level. This indicates that when the degree of industrial structure upgrading is higher than the second threshold, the positive promotion effect of digitalization on the convergence of rural primary, secondary, and tertiary industries becomes more significant. When the digitalization level increases by one unit, it can drive the convergence level of rural industries to increase by 0.3699 units. Therefore, only when the industrial structure of a region is optimized and upgraded to a certain extent can digitalization effectively play its driving role in rural industrial convergence. The higher the level of industrial structure upgrading, the better the driving effect on rural industrial convergence. In summary, Hypothesis 2 is proven.

Table 7. Regression results of panel threshold model.

Variable	Regression Coefficient [1]	*t*-Value
IS < 0.8629	−0.0379	−0.673
0.8629 ≤ IS ≤ 0.9027	0.1728 ***	3.327
IS > 0.9027	0.3699 ***	8.628
FIS	−0.0183	−1.575
TIN	0.0704 **	2.329
EXP	−0.0007 ***	−6.183
RF	−0.0218 ***	−3.148
RHC	−0.0617	−0.958
PGDP	0.0642 ***	2.780
DIP	0.0232 ***	4.202
Constant	−0.3429	−1.574
Observations	300	
R-squared	0.748	

[1] *** $p < 0.01$, ** $p < 0.05$.

4.3. Robustness Test and Endogenous Discussion

Although this paper selects a two-way fixed effect model in empirical analysis and uses clustering robust standard error in regression to overcome possible endogeneity, the level of rural industrial convergence is likely to be influenced by the existing convergence foundation in the past, resulting in bias in empirical estimation results. Therefore, this paper uses commonly used methods to add the first-order lag term of the explained variable (rural industrial convergence) to the model and uses the two-step Sys-GMM model for endogeneity test to obtain the regression results shown in Table 8. It can be seen that the AR (1) test results are significant, while the AR (2) and Hansen's test results are both greater than 0.1 and not significant. This indicates that there is no higher-order autocorrelation and over-recognition problem, so the test results of the Sys-GMM are effective. At the same time, the regression coefficients of digitalization of Model (1) and (2) both show positive values and are significant at the 1% level, consistent with the full-sample benchmark regression results. Therefore, it can be considered that the empirical test results of the impact of digitalization on rural industrial convergence in this paper are reliable.

At the same time, in order to ensure the reliability and effectiveness of the empirical results, it is necessary to further carry out the robustness test. Due to the possibility of lagging effects in macroeconomic variables, the digital construction of that year may not have a significant impact on rural industrial convergence in time, but will have an effect in subsequent years. Therefore, this paper uses the research methods commonly used to carry out the robustness test by regressing the explanatory variables once again after a period of lag. According to the test results in Table 8, the regression coefficient of digitalization is still significantly positive at the level of 1%, which indicates that the previous corresponding empirical results are robust.

Table 8. Regression results of Sys-GMM and robustness.

Variables	(1) Sys-GMM [1]	(2) FE	(3) FE
L.RIC	0.9366 ***	0.6703 ***	
	(15.51)	(9.79)	
Dig	0.2310 ***	0.2623 ***	
	(3.07)	(3.53)	
L.Dig			0.4840 ***
			(3.16)
Control Variables	Controlled	Controlled	Controlled
Constant	0.1958	−0.2396	−0.2560
	(1.07)	(−0.67)	(−0.39)
Observations	270	270	270
Yearly Dummy Variables	Controlled	Controlled	Controlled
R-squared		0.810	0.653
AR (1)	0.047		
AR (2)	0.933		
Hansen's test	0.705		

[1] *t*-statistics in parentheses, *** $p < 0.01$.

4.4. Discussion on the Research Results

The discussion on the theoretical and empirical research results is as follows.

On the theoretical research results, we conclude the following. (1) In terms of promoting the extension of the agricultural industry chain, digitalization can play an important role in enhancing information exchange, reducing information asymmetry, promoting rational and efficient resource allocation, reducing transaction costs, and improving production rates in various aspects such as production and processing, storage and transportation circulation, supply and demand linkage, and technology R&D. This makes the connection between the upstream, midstream, and downstream of the industry chain closer, and the supply chain smoother. At the same time, digitalization can enhance the modern operation and management capabilities of new agricultural operation entities, promote the transformation and upgrading of traditional agricultural operation entities to new ones, and strengthen the interest connection between them. (2) In terms of the expansion effect on the multifunctional utilization of agriculture, big data and digital technology can further tap into the potential of agricultural production, ensure and improve the quality of agricultural products, and thus promote the utilization of agricultural economic functions. By utilizing digital monitoring control and precise decision making, agricultural ecological functions can also be improved. The Internet and digital platforms provide diverse communication channels and trading platforms for leisure agriculture, enhancing consumers' sense of experience and participation and assisting operation entities in their management. (3) On the optimization effect of multi-factor integration and development, digitalization can effectively reduce information asymmetry, promote capital flow between urban and rural areas, and strengthen the competition of financial institutions to improve the credit system, so as to fully mobilize financial capital into the field of rural industrial convergence. By improving the level of rural human capital and attracting talents to gather in rural areas, digitalization can also promote the improvement of agricultural industry innovation capabilities [19,20,28]. Due to the progress of digital technology, the boundaries of industries have been further blurred, and the integration of factors has been strengthened, resulting in innovative development of new rural business forms. And location plays a less important role in promoting convergence and territorial development in rural areas.

On the empirical research results, we conclude the following. (1) By constructing a two-way fixed effect model of digitalization on rural industry convergence, it is empirically concluded that both digital infrastructure and digital applications can promote the convergence of rural primary, secondary, and tertiary industries, and the impact of digital infrastructure is stronger than that of digital applications. Digitalization has a significant positive promoting effect on the extension of the agricultural industry chain, the utilization of agricultural multifunctionality, and the integration of factors, among which the promoting effect on the extension of the agricultural industry chain and the utilization of agricultural multifunctionality is greater than that on the integration of factors. There are significant differences in economic development level, agricultural production scale, and infrastructure construction among different regions in China. The positive effect of digitalization on rural industrial convergence varies across different regions in China, with a more pronounced effect in East China than in Midwest China, and a more pronounced effect in major grain-producing areas than in non-major grain-producing areas [25,26]. (2) By constructing a threshold effect model based on industrial structure, it is empirically concluded that under different industrial structures, digitalization has a dual threshold driving effect on the convergence of rural primary, secondary, and tertiary industries. When the degree of industrial structure upgrading is lower than the first threshold, the impact of digitalization on rural industrial convergence is not significant. When it is between the first and second thresholds, digitalization can significantly promote rural industrial convergence. When it exceeds the second threshold, the degree of digitalization driving the converged development of rural industries is greater, showing a stepped strengthening trend. It indicates that the above regional heterogeneity is based on industrial structure.

To ensure the reliability of the results, we also compare the results of this study with other relevant studies, as shown in Table 9. From the table, it can be seen that both this paper and the others use a self-built indicator system to evaluate the level of rural industrial converged development, using the entropy-weighted TOPSIS method to synthesize indicators, and using the Sys-GMM. Zhang and Wen (2022) use spatial analysis and Sargan's test to test over-recognition, while this paper, like the other two papers, uses panel data regression and Hansen's test. In terms of the number of secondary indicators in the rural industrial converged development level indicator system, we select eight indicators, which is a moderate number. We also select eight control variables and consider them comprehensively [24,40,41].

Table 9. Comparison between this paper and other studies.

Item	This Paper	Zhang and Wen (2022) [24]	Wang and Li (2019) [40]	Li and Ran (2019) [41]
A self-built indicator system for evaluating the level of rural industrial converged development	Yes	Yes	Yes	Yes
Number of secondary indicators in the indicator system for rural industrial converged development level	8	9	5	5
Entropy-weighted TOPSIS method used	Yes	Yes	Yes	Yes
Spatial metrology used	No	Yes	No	No
Sys-GMM used	Yes	Yes	Yes	Yes
Overidentification testing method	Hansen's Test	Sargan's Test	Hansen's Test	Hansen's Test
Number of control variables	8	8	5	6

4.5. Limitations of the Study and Areas for Further Research

From the empirical results, the limitations of this paper are as follows. Firstly, with China's provincial panel data as the data source for empirical analysis, the results may be applicable to China or countries similar to China's national conditions but may not have global universality. Secondly, due to the availability of data, the study only uses the provincial data of China, but did not analyze the prefecture-level data. Thirdly, the coupling between rural and urban industrial convergence is not completely analyzed due to the fact that the development of urban and rural industry is different.

Considering the above limitations, future research on digitalization driving the converged development of rural industries can use the prefecture panel data for empirical analysis. Research involving different countries or regions is also needed, which can make the application of digitalization in rural development more widespread. In addition, it is better if the research can address the industrial development gap between urban and rural areas.

5. Research Conclusions and Recommendations

5.1. Research Conclusions

This paper studies the impact of digitalization on the convergence of primary, secondary, and tertiary industries in rural areas. Through in-depth theoretical and empirical research, the main conclusions are as follows:

(1) This paper's theoretical research reveals that digitalization mainly drives the high-quality converged development of rural primary, secondary, and tertiary industries in three ways: promoting the extension of the agricultural industry chain, promoting the multifunctional utilization of agriculture, and promoting the integration of factors. Digitalization makes location less important and it connects rural and urban areas, building rural–urban continuums.
(2) The empirical research shows that digitalization can significantly promote the converged development of rural primary, secondary, and tertiary industries, and this impact effect has regional heterogeneity. At the same time, its promoting effect also varies under different industrial structures.

5.2. Recommendations

Based on the conclusions above, this paper proposes the following recommendations:

(1) Accelerate the construction of digital infrastructure and forge strong support for convergence. It is necessary to improve both hard and soft conditions of rural digital infrastructure.
(2) Strengthen the digital application of rural industries and enhance the depth of convergence. On the one hand, increase the strength and breadth of policy support from the government, and continue to help digital transformation and upgrading of the entire agricultural industry chain. On the other hand, accelerate the cultivation of talents related to digitalization in rural industries and enhance the application level and efficiency of digital resources in rural industrial convergence.
(3) Promote regional coordinated development and expand inclusiveness of convergence. On the one hand, it is to carry out digital upgrading of rural industries according to local conditions and develop the convergence of rural industries. On the other hand, it is to strengthen regional exchanges and cooperation and promote regional interconnected development.
(4) Establish a sound institutional system to promote sustainable convergence. On the one hand, establish and improve a legal and supervisory system for the digital development of rural industries. On the other hand, further improve the construction of the institutional system for the converged development of rural industries.

The visualization of the above recommendations is shown in Table 10.

Table 10. Visualization of the recommendations.

Criterion	Recommendation	Detail
Digital infrastructure	Improve rural hard conditions	Enhance the construction of high-speed network infrastructure
		Strengthen the intensive construction and co-construction and sharing of facilities
		Promote the digital upgrading of traditional infrastructure
		Ensure the availability of digital infrastructure in rural areas
	Improve rural soft conditions	Promote the width and depth of digital infrastructure software coverage in rural areas
		Increase the construction and resource integration of digital platforms for rural comprehensive information services

Table 10. *Cont.*

Criterion	Recommendation	Detail
Digital application	Increase the strength and breadth of policy support	Give preferential policies to the digital transformation and up-grading of rural industries
		Increase investment
		Provide preferential policies to guide high-tech and digital enterprises
	Accelerate the cultivation of talents related to digitalization in rural industries	Actively utilize existing talents in digitalization
		Further attract talents in digitalization and lead them to rural areas
		Continuously promote the cultivation of "new agricultural talents"
Regional heterogeneity	Carry out digital upgrading of rural industries according to local conditions	Carry out further construction based on local needs
		Utilize digitalization from the actual regional resource endowment
	Strengthen regional exchanges and cooperation and promote regional interconnected development	Break regional division and strengthen the cross-regional flow of resource factors
		Adhere to the implementation of a corresponding assistance mechanism
		Utilize digitalization to promote regional coordinated development
Institutional system	Establish and improve a legal and supervisory system	Promote the improvement of the legal system for the application of digitalization in rural industries
		Accelerate the formulation of relevant laws and regulations required in the application of digitalization in rural industries
		Accelerate the improvement of the supervision system for the application of digitalization in rural industries
	Further improve the construction of the institutional system	Make strategic planning
		Strengthen the guarantee of corresponding factors
		Carry out the selection of excellent demonstration parks to play an exemplary role

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