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From Chain Extension to Synergy: Pathways for High-Quality Development of Henan's Cotton Textile Industry

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ABSTRACT

This study investigates the synergistic effect between the extension of Henan's cotton textile industrial chain and the integration of primary, secondary, and tertiary agricultural industries, aiming to provide insights for regional agricultural modernization and sustainable economic growth. An evaluation framework was established, incorporating industry chain extension, industrial integration, and synergy indicators. Using data from 2014–2024, the entropy value method was applied to determine indicator weights, while the coupling coordination model and panel regression analysis were used to assess interactions and benefits. Case studies of Xinxiang, Anyang, and Nanyang further illustrated the micro-mechanisms of these empirical results. The findings demonstrate sustained growth in both Henan's cotton textile industrial chain extension and three-industry integration, increasing from 0.28 in 2014 to 0.61 in 2024, indicating a transition to a benign interaction stage. Regression results confirm significant positive impacts: industry chain extension and integration enhanced farmers' income, employment, and narrowed the urban–rural gap, while integration exerted a stronger influence on ecological benefits such as green production and emission reduction. Regional analysis highlights Xinxiang achieving a high synergy level of 0.74 in 2024 due to industrial clustering and innovation, while some cotton-producing areas remain at medium levels due to weak chain linkages. In conclusion, the extension of the cotton textile chain and agricultural three-industry integration have become key drivers of Henan's high-quality agricultural economy, with policy and innovation essential for further promoting value-added processing, service industry integration, and sustainable development.

KEYWORDS

industry chain extension, agricultural integration, synergistic, coupling coordination degree

INTRODUCTION

As an important agricultural province and textile industry base in China, Henan Province occupies a pivotal position in the pattern of national grain and cotton main production areas [1]. Cotton is not only one of the core crops in Henan's agricultural structure, but also a key raw material to promote the development of the textile industry [2]. For a long time, cotton planting, spinning, and weaving, and related industries in Henan have formed a relatively complete industrial chain, but overall, there are still problems such as insufficient extension of the industrial chain, constrained potential for value-added growth, and upstream and downstream synergistic effects that cannot be fully released [3]. With China's promotion of structural reform of the agricultural supply side and the implementation of the rural revitalization strategy, the extension of the cotton textile industry chain and the integration of the three sectors of the agricultural economy are becoming increasingly close, and it is urgent to systematically explore the mechanisms and paths of their synergistic development [4,5]. From the perspective of the agricultural economy, cotton planting in the primary industry provides a solid raw material base for the textile industry, spinning, weaving, printing and dyeing and garment processing in the secondary industry extends the agricultural production chain, and distribution, brand building, cultural creativity and rural tourism in the tertiary industry further expands the industrial value space [6]. The integration of tertiary industries can not only enhance the comprehensive benefits of agriculture, but also facilitate the transfer of rural labor and promote balanced regional development. Henan's cotton textile industry plays a pivotal role in, agricultural modernization and industrial transformation and upgrading in this process, and is the key fulcrum for achieving agricultural efficiency, farmers' income, and rural prosperity.

Henan Province has actively promoted the extension and optimization of the cotton textile industry chain, forming textile industry clusters with Xinxiang, Anyang, Nanyang, and other places as the core [7]. Relying on the construction of modern agricultural industrial parks, agricultural science and technology innovation platforms, and rural industrial integration development demonstration zones, the agricultural and textile industries are gradually showing a trend of synergistic development in terms of raw material supply, technological innovation, market expansion, and branding [8]. Especially under the guidance of the national "dual-carbon" strategy and green manufacturing policy, the extension of the cotton textile industry chain and the integration of the three sectors of the agricultural economy are not only reflected in the economic level of synergy,

but also involve the comprehensive enhancement of ecological and social benefits [9]. However, in the process of practical promotion, Henan cotton textile industry chain extension and agricultural integration of the three industries still face some constraints, for example: the upstream and downstream convergence of the industry chain is not close enough, the development of high-end links in the value chain is insufficient, the mechanism of inter-regional synergy has not yet been perfected, and the mechanism of interest linkage between farmers and enterprises needs to be innovated [10-12]. The existence of these problems, to a certain extent, limits the full play of industrial synergies. How to extend and optimize the cotton textile industry chain, promote the deep integration of agricultural one, two, and three industries, and achieve a higher level of synergy of economic, social, and ecological benefits has become a major issue that needs to be studied and solved.

In this paper, we systematically review domestic and international studies on industrial chain extension, agricultural three-industry integration, and their synergistic effects, and identify gaps in the existing literature. We then describe the construction of the indicator system, the data sources and methodological framework, including the entropy value method, the coupling coordination model, and panel regression analysis. Based on empirical data from Henan Province covering 2014–2024, we evaluate the levels of industrial chain extension, three-industry integration, and synergy, and discuss the results through representative regional cases to derive policy implications and directions for future research.

LITERATURE REVIEW

In recent years, research on the extension of the agricultural industry chain and the integration of the three industries has gradually become an important topic in academia and policy research [13,14]. The existing literature mainly focuses on the following three aspects: first, the theory and practice path of industry chain extension, second, the mode and mechanism of agricultural three industries integration, and third, the relationship between the cotton textile industry and regional economic development. These research results provide theoretical support and experience for the extension of the cotton textile industry chain in Henan and the analysis of the synergistic effect of the integration of the three industries in the agricultural economy.

Industrial Chain Extension

The core of industrial chain extension is to promote the extension of agriculture to processing, circulation, and service links to enhance the added value of products and comprehensive benefits [15]. Domestic scholars generally believe that extending the agricultural industry chain can promote the optimal allocation of resources and industrial upgrading, and form a complete value chain system. For example, some studies point out that agricultural product processing and brand building are the key links in the extension of the industry chain, which can effectively enhance the competitiveness of the industry by increasing technological innovation and market expansion [16,17]. In international studies, agricultural industry chain extension is usually placed under the framework of the global value chain, emphasizing the embedding of high-end links in the value chain through standardization, informatization, and greening means [18]. These studies provide ideas that can be drawn on for the extension of Henan's cotton textile industry, but the systematic analysis of the regional characteristic industry chain is still relatively insufficient.

Integration of 'Three Industries' in Agriculture

Three-Industry Integration is an important path of agricultural modernization, and its essence is the deep coupling between primary industry and secondary and tertiary industries [19]. Existing researches are mostly carried out from the perspectives of integration mode, driving mechanism, and policy support [20]. Domestic scholars have put forward a variety of integration modes, such as "industry chain-driven", "scientific and technological innovation", "rural tourism", etc., as shown in Table 1 below, emphasizing that different regions should choose differentiated paths according to their resource endowments. It is emphasized that different regions should choose differentiated paths according to their resource endowments.

Table 1. Classification and summarization of typical models of agricultural three-product integration by domestic scholars

Integration Mode	Main features	Typical cases
Industry Chain Driven	Emphasizing the extension and deep coupling of the industrial chain and promoting the mutual integration of primary, secondary, and tertiary industries.	A place in Henan Province realizes the synergistic development of agriculture and the textile industry through the deep cooperation between cotton planting and processing enterprises.

Science and technology are innovative.	Driven by technological innovation, it promotes the deep integration of agriculture with industry and the service industry, and enhances industrial value through scientific and technological progress.	Agricultural Science and Technology Park in Zhejiang Province, leading the deep processing of agricultural products and the integration of agriculture and the manufacturing industry through technology.
Rural Tourism	Combining the natural resources and agricultural characteristics of the countryside, promoting the integrated development of agriculture, tourism, and cultural industries, and enhancing the added value of agriculture.	The "agriculture and tourism" model in a place in Sichuan Province promotes rural tourism through the integration of agriculture and local cultural resources.
Ecological Agriculture	Focusing on the coordinated development of ecological protection and agricultural production, promoting the integration of agriculture with environmental protection and green development.	Eco-agricultural zones around Beijing realize green agricultural production through the combination of organic agriculture and environmental protection.
Agricultural Finance	Emphasizes the combination of agricultural production and financial services, and promotes the development of agricultural industrialization through financial support.	Rural financial services launched by the Agricultural Bank of Shandong Province to provide financial support for agricultural cooperatives and promote the integration of the three industries.

Table 1 presents domestic scholars' summarization of typical models of agricultural three-product integration, specifying five major integration models and briefly describing each model. Through the summarization and comparison of these typical models, it can be seen that the paths of agricultural three-industry integration are diversified, and different regions have chosen different integration models to promote the in-depth integration of agriculture and other industries according to their own resource endowments and industrial characteristics. However, the implementation of these models also faces certain challenges, especially in resource integration, industrial synergy, and policy support [21]. International scholars, on the other hand, pay more attention to the multifunctionality and sustainable development of agriculture, combine the integration of the three industries with rural community development and ecological protection, and emphasize the social and environmental benefits in the integration process [22]. On the whole, relevant studies have revealed the generalized law of agricultural three-industry integration in Henan, but they lack in-depth exploration of the specific integration effect of advantageous industrial chains such as cotton textile [23].

Cotton Textile Industry and Regional Economy

As an industry that is both labor-intensive and technology-intensive industry, the cotton textile industry has long played an important role in regional economic development [24]. Domestic research on the cotton tex-

tile industry focuses on the formation of industrial clusters, optimization of regional layout, and green transformation and upgrading [25]. Some scholars have pointed out that the integration degree of the upstream and downstream of the textile industry chain directly affects the competitiveness of the industry and the sustained growth of the regional economy [26]. Overseas research focuses more on the division of labor in the global value chain of the textile industry, technological innovation, and trade pattern changes, and emphasizes the importance of improving the resilience of the textile industry chain [27,28]. However, existing studies often overlook the specific resource endowments and constraints of Henan Province. In particular, facing the hard constraints of water scarcity in the Yellow River basin, the reduction of planting area under strict arable land protection policies, and fierce market competition from Xinjiang cotton, current literature fails to deeply explore how Henan can overcome these structural contradictions through the synergy mechanism of 'industry chain-agriculture'. Consequently, the existing theoretical frameworks struggle to fully explain the resilient growth mechanism of Henan's cotton textile industry under resource constraints. These research results provide theoretical references for deepening the extension of the cotton textile industry chain in Henan Province and enhancing the synergistic effect of integration with agriculture, but the degree of system integration still needs to be strengthened.

Shortcomings

To summarize, existing research on the extension of the agricultural industry chain and the integration of the three industries has a more systematic discussion of the theoretical framework, mode classification, and role mechanism, and also provides an empirical summary of the development of the cotton textile industry. However, there are three deficiencies in the existing studies: 1st, the interaction between the regional characteristic industrial chain and the integration of the three industries is not enough attention, and there is a lack of empirical research combining quantitative and qualitative; 2nd, the comprehensive research on the economic, ecological and social benefits of the industrial chain extension is still weak; 3rd, the mechanism of the synergistic effect of the integration of the cotton textile industrial chain and the three industries of the agricultural economy in Henan has not yet been analyzed systematically. Therefore, it is necessary to combine the specific practice of Henan cotton textile industry chain on the basis of previous studies to explore the interactive mechanism and synergistic effect of industry chain extension and integration of the three industries.

MATERIAL AND METHODS

Data Sources

The research data mainly includes three categories: (1) Statistical data. Annual data from Henan Provincial Statistical Yearbook, China Cotton Yearbook, Henan Provincial Department of Agriculture and Rural Development, and Department of Industry and Information Technology, covering cotton planting area, output, processing output value, textile industry output value, related employment population, and industry added value, and other indicators. Given the time lag in statistical yearbooks, data for 2023 and 2024 were supplemented and calibrated using monthly statistical bulletins released by the Henan Provincial Department of Industry and Information Technology and annual express reports from relevant industry associations. (2) Research data. Through field research in Xinxiang, Anyang, Nanyang, and other major cotton textile industry clusters, we collected information on the operation of enterprises, the income structure of farmers, the operation mode of cooperatives, and the construction of industrial parks. The research used a combination of questionnaires, in-depth interviews, and symposiums, covering large cotton farmers, cooperative leaders, textile enterprise executives, and personnel from relevant local government departments. (3) Secondary data. Including domestic and international academic journal literature, industry development reports, policy documents, and related think tank research results for theoretical comparison and framework supplementation.

Framework and Indicator System

Framework

In order to systematically reveal the synergistic effect of the extension of Henan's cotton textile industry chain and the integration of the three industries in agriculture, this study constructs a research framework of "three-layer structure - two-way interaction - effect measurement". The framework emphasizes the two-way interaction between industry chain extension and three industries integration, i.e., industry chain extension promotes the deepening of three industries integration, and three industries integration, in turn, promotes the expansion of industry chain value.

Figure 1 shows the structure of the research framework. It specifically includes three levels:

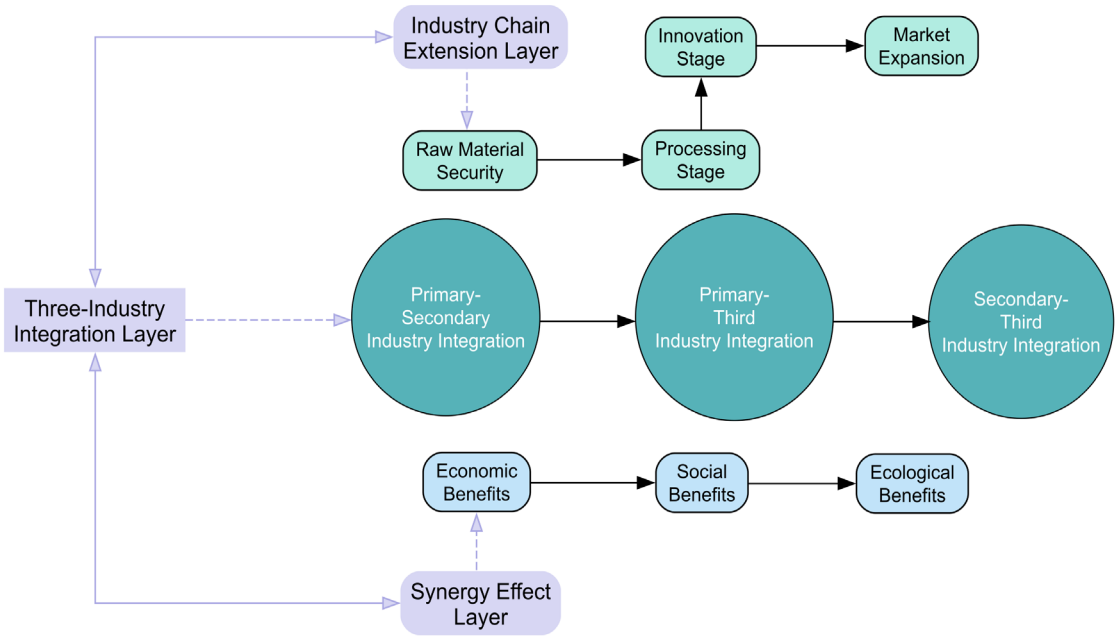

Figure 1. Structure of the research framework

The industry chain extension layer, which mainly examines the degree of vertical extension of cotton from cultivation to spinning, weaving, dyeing, and garment processing, as well as the expansion in technological innovation and brand building.

The tertiary integration layer analyzes the horizontal integration of agricultural production with the processing industry and service industry, focusing on the degree of integration between the cotton textile industry and tertiary industries such as logistics, finance, culture, and tourism.

Synergistic effect layer, researching the interaction between industry chain extension and tertiary industry integration in terms of economic, social, and ecological benefits.

Design of the Indicator System

To realize the quantification of the research framework, this study designs an indicator system covering three dimensions. Table 2 demonstrates the indicator system of industry chain extension, three industries integration, and synergistic effect designed by this study, which covers three dimensions, with several specific indicators under each dimension, aiming to measure the synergistic effect and integration development of the cotton textile industry in Henan Province through quantitative analysis. The system provides a clear framework for quantitative research, which helps to analyze the synergistic effect of industry chain extension and

integration of three industries in depth, and then provides a theoretical basis and policy support for promoting the high-quality development of Henan's cotton textile industry [29].

Table 2. Indicator system of industrial chain extension, three Industries integration and synergy effect

Indicator category	Indicator dimension	Specific indicators
Industry chain extension indicators	Raw material security	Cotton planting area, cotton yield per unit area (kg/ha), and proportion of high-quality cotton
	Processing	Cotton textile output value accounted for the proportion of total agricultural output value, textile deep processing ratio
	Innovation	R&D investment ratio, new product output value ratio, and number of patents
	Market Expansion	Number of brands, percentage of export value, and domestic market share
	Integration of primary and secondary industries	Ratio of agricultural products processing rate, agricultural products processing industry output value
Indicators of integration of the three industries	Integration of one and three industries	Number of cooperations between agriculture and e-commerce platforms, income from agro-cultural tourism
	Integration of secondary and tertiary industries	Ratio of inputs from the textile industry to logistics, finance, and cultural and creative industries
Synergy effect indicators	Economic Benefits	Growth rate of per capita income of farmers, growth rate of cotton textile industrial added value
	Social Benefits	Scale of employed population, degree of farmers' organization, ratio of urban to rural disposable income
	Ecological Benefits	Utilization efficiency of fertilizers and pesticides, energy saving, and emission reduction level, proportion of clean production enterprises

Note: To ensure data comparability, all monetary indicators are adjusted to constant prices with 2014 as the base year. The "Urban-rural disposable income ratio" is treated as an inverse indicator, with lower values corresponding to a higher level of synergistic development.

Model and Method Design

Synergy Measurement Model

In order to quantify the synergistic effect of industry chain extension and three industries integration, this study introduces the synergy degree model. The degree of synergy reflects the degree of coordination between two or more systems in interaction, and is commonly used in the study of regional economy and industrial integration. The specific equation is:

$$U_{12} = \mathrm{C} = \sqrt{\frac{U_1 \times U_2}{\left(U_1 + U_2\right)^2}} \quad (1)$$

Where U_1 is the index of industry chain extension, U_2 is the index of three industries integration, and U_{12} is the index of the coupling effect of the two. When C approaches 1, this indicates a strong level of synergy between the two systems.

Entropy Value Method and Comprehensive Evaluation

In terms of indicator assignment, the entropy value method is used to determine the weight of each indicator to avoid the problem of excessive subjectivity. The entropy value method calculates the weights through the data's discrete degree of the indicators, which can objectively reflect the importance of the indicators. The specific process includes: data standardization, entropy value calculation, redundancy calculation, and weight determination.

Empirical Test Method

Based on synergy measurement, this study further adopts regression analysis and a panel data model to examine the impact of industry chain extension and three industries on economic, social, and ecological benefits. Specific methods include:

Fixed effects model. Used to examine the differences between different years and different regions.

Correlation test. To test the interaction between the degree of industry chain extension and the degree of integration of the three industries.

Sensitivity analysis. To test the robustness of the results under different indicator systems.

A Combination of Qualitative and Quantitative Methods

In addition to quantitative analysis, this study will also utilize case analysis and comparative research methods, selecting typical areas such as Xinxiang, Anyang, and Nanyang as cases to deeply analyze the specific patterns and practical paths of cotton textile industry chain extension and three industries integration. The selection of these three cities is based on two primary criteria: Industrial Scale, as their combined gross out-

put value accounts for over 60% of the province's total cotton textile industry; and Typological Representation, with Xinxiang representing a complete industrial chain model, Anyang a deep-processing driven model, and Nanyang an agriculture-tourism integration model. Through the combination of qualitative and quantitative methods, the formation mechanism of the synergistic effect can be revealed more comprehensively.

RESULTS AND DISCUSSION

Industry Chain Extension Measurement

According to the index system of industrial chain extension degree designed in the previous part, the entropy value method is used to assign weights to each index, and the index of the cotton textile industry chain extension degree in Henan Province is calculated. The results show that during the period of 2014-2024, the extension degree of the cotton textile industry chain in Henan Province as a whole shows a trend of steady improvement. Among them, the ability to guarantee cotton raw materials remains stable, and the level of yields has slightly increased, but the main factors that really promote the growth of the extension are the processing link and the innovation link. Data show that between 2014 and 2024, the deep processing ratio of cotton textiles in Henan Province increased from 36.2% to 54.7%, and the output value rate of new products increased from 7.3% to 15.8%, indicating that the industrial chain has made substantial progress in vertical extension and technological innovation. Specific data are shown in Table 3.

Table 3. Cotton textile industry chain extension index and score of sub-indicators in Henan Province, 2014-2024

Year	Raw material security	Processing link	Innovation link	Market Expansion	Total Index of Industry Chain Extension	Xinxiang	Anyang	Nanyang	Other Regions
2014	0.72	0.60	0.50	0.55	0.59	0.62	0.58	0.60	0.55
2015	0.74	0.62	0.52	0.56	0.61	0.64	0.60	0.62	0.59
2016	0.76	0.64	0.54	0.58	0.63	0.67	0.63	0.65	0.61
2017	0.77	0.66	0.56	0.60	0.65	0.69	0.65	0.67	0.63
2018	0.79	0.68	0.58	0.61	0.68	0.72	0.69	0.71	0.66
2019	0.80	0.70	0.60	0.62	0.71	0.75	0.72	0.74	0.68
2020	0.81	0.72	0.62	0.64	0.73	0.77	0.74	0.76	0.70
2021	0.83	0.74	0.64	0.65	0.76	0.79	0.77	0.78	0.74
2022	0.84	0.76	0.66	0.67	0.78	0.81	0.79	0.80	0.76
2023	0.85	0.79	0.69	0.70	0.81	0.83	0.81	0.83	0.78

2024	0.86	0.82	0.71	0.72	0.84	0.85	0.83	0.85	0.80

Figure 2 shows the heat map of the industry chain extension index of each region from 2014 to 2024. The colors in the map represent different index values: colors closer to red indicate higher industry chain extension levels, whereas colors closer to blue indicate lower levels. The extension index of the three major industrial clusters of Xinxiang, Anyang, and Nanyang is significantly higher than that of other regions, mainly due to the industrial agglomeration effect and the driving effect of leading enterprises. For example, the Xinxiang region relies on the R&D investment of large textile enterprises and the construction of industrial parks, and its innovation link extension score reaches the highest value in the province. In contrast, the extension index of some central and western counties has been relatively slow to improve, mainly due to insufficient upstream and downstream convergence of the industrial chain, and low levels of agricultural product processing rate and brand building.

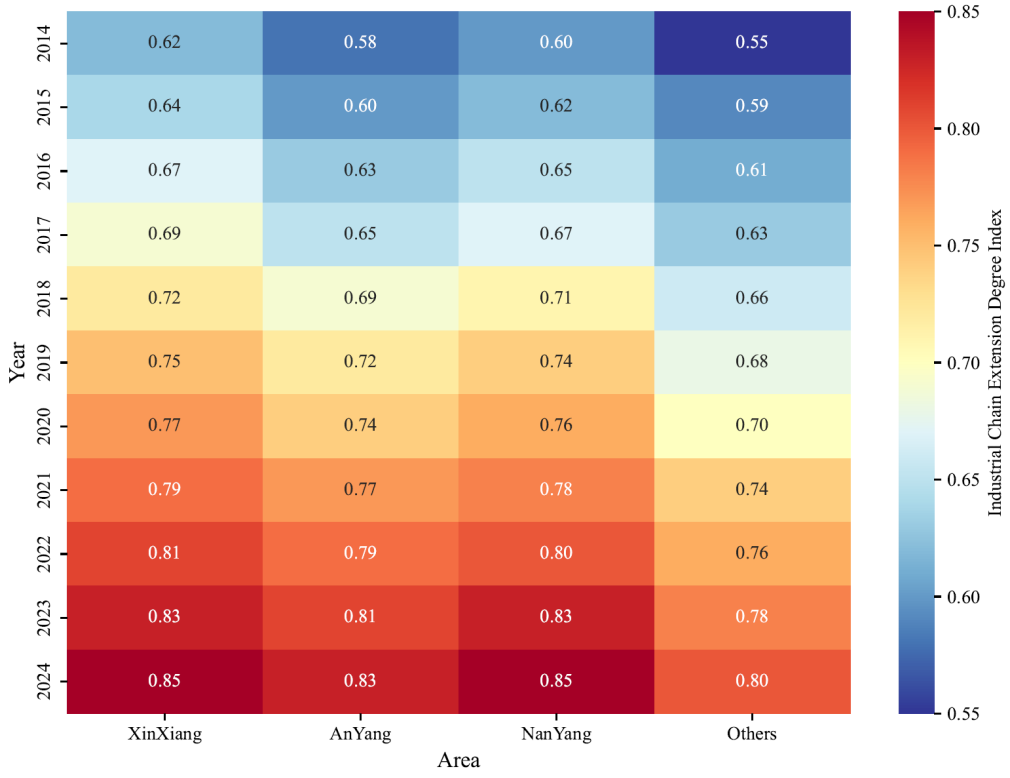

Figure 2. Heat map of Industry Chain Extension Index by region, 2014-2024

Measurement Results of the Integration Degree of Three Industries

Utilizing the constructed index system of the integration degree of the three industries and empowered by the entropy value method, the index of the integration degree of the three industries of the cotton textile industry in Henan Province is calculated. Table 4 below demonstrates the three-industry integration index of Henan Province's cotton textile industry and its sub-indicator scores from 2014 to 2024. Through the quantitative analysis of the integration of the three industries, we can see that the integration of the cotton textile industry in Henan Province during this decade has shown an overall upward trend, with the integration of the three industries increasing from 0.32 in 2014 to 0.57 in 2024, indicating that the combination of agriculture with the secondary and tertiary industries has been gradually strengthened, which promotes the modernization of agriculture and the upgrading of industries.

Table 4. Index of the integration degree of three industries and score of sub-indicators of cotton textile industry in Henan Province, 2014-2024

Year	Integration of primary and secondary industries	Integration of primary and tertiary industries	Integration of the two or three industries	Overall index of tertiary integration
2014	0.40	0.25	0.21	0.32
2015	0.42	0.27	0.23	0.34
2016	0.45	0.30	0.26	0.36
2017	0.48	0.33	0.30	0.37
2018	0.50	0.35	0.33	0.39
2019	0.53	0.37	0.36	0.41
2020	0.55	0.40	0.39	0.43
2021	0.57	0.42	0.42	0.46
2022	0.60	0.45	0.45	0.50
2023	0.61	0.48	0.48	0.53
2024	0.62	0.50	0.53	0.57

As can be seen from the data in Table 4, in terms of the integration of primary and secondary industries, the processing rate of agricultural products has continued to increase, reaching 62.4% in 2024, up 21.5 percentage points from 2014. Especially in the Anyang and Nanyang areas, the agricultural production chain has been effectively extended through the development of cottonseed oil processing and by-product utilization. In addition to the integration of one or three industries, Henan actively promotes the development of cotton

cultural tourism. Xinxiang Textile Museum and Nanyang City's "Cotton Culture Festival" have become a typical case of the deep integration of agriculture and tourism [30]. In 2022, the province's rural tourism income related to cotton increased by nearly 2.3 times compared with 2015. It can be seen that the combination of the cotton textile industry with e-commerce, logistics, and finance has been further deepened. In 2024, the e-commerce sales of textile products in Henan Province increased by 4.7 times compared with 2014, promoting the expansion of the value space of the industrial chain.

Figure 3 is a stacked area chart showing the changes in different industrial integration indices between 2014 and 2024. The figure includes four different industrial integration indices: primary and secondary industrial integration are represented by the lightest color. As can be seen from the graph, this index shows a slow but relatively small increase throughout the time period. The integration of primary and tertiary industries is represented by a slightly darker color. This index also shows a growing trend and a slightly larger growth than the integration index of one and two industries. The integration of two and three industries is represented by a darker color. This index shows the most pronounced growth trend, indicating that the integration of the two and three industries is accelerating. Tertiary integration is indicated by the darkest color. This index also shows a significant growth trend throughout the time period, indicating that the integration of the three industries is increasing.

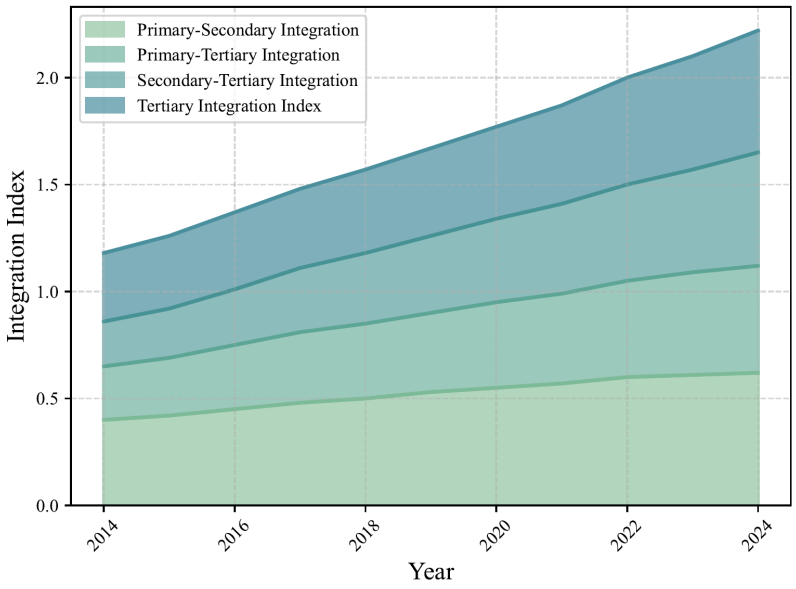

Figure 3. Stacked area map of industrial integration, 2014-2024

Synergy Index Measurement

On the basis of the measurement of industry chain extension and integration of three industries, the synergy effect index of the cotton textile industry in Henan Province is calculated by using the synergy model. The results show that the synergistic effect index increased from 0.28 to 0.61 from 2014 to 2024, and the whole show the trend of gradually developing from a low level of coordination to a higher level of coordination. Specifically, the synergistic effect rose more slowly in 2014-2018, mainly due to the large disconnection between the raw material guarantee in the upstream of the industrial chain and the service extension in the downstream. And since 2019, as Henan Province vigorously pushes forward the structural reform of the agricultural supply side, the synergistic effect index has seen a significant increase, especially during the period of 2021-2024, when the increase is most obvious. In this stage, the synergistic development of the agricultural product processing industry, rural tourism, and textile industry is increasingly prominent.

Figure 4 shows the regional contributions of different regions in Henan Province to the cotton textile industry collaboration effect index between 2014 and 2024. Different colored dots are used in the figure to represent the contribution of different regions, where blue represents the Xinxiang region, green represents the Anyang region, orange represents the Nanyang region, and red represents other regions. From the figure and combined with Table 5, it can be concluded that the synergy indexes of Xinxiang, Anyang, and Nanyang are all higher than the average level of the province, with Xinxiang reaching 0.74 in 2024, which is close to a highly coordinated state. In contrast, some cotton planting areas are still at a low to medium level of synergistic effect index due to the lack of industrial chain convergence.

Figure 4. Regional contribution of cotton textile industry collaboration effect index in Henan Province (2014-2024)

Regression Analysis

In order to further verify the impact of industry chain extension and integration of three industries on economic, social, and ecological benefits, this study uses the panel data fixed effect model for regression analysis. Figure 5 below demonstrates the results of the distribution of the effect size of industry chain extension and three industries' integration on three different types of benefits: economic, social, and ecological benefits.

Effect on economic benefits. Both the degree of industry chain extension and the degree of three-product integration are significantly and positively correlated with the growth rate of farmers' per capita income. Among them, the regression coefficient of the industry chain extension degree is 0.326, and the regression coefficient of the degree of integration of the three industries is 0.412, indicating that both of them can significantly enhance the farmers' income, and the role of the integration of the three industries is more prominent.

Impact on social benefits. The degree of industry chain extension and the degree of integration of the three industries both show significant positive effects on the size of the employed population and the rate of reduction of the urban-rural income gap. The data show that for every 0.1 unit increase in the degree of integration of the three industries, the rate of reduction of the urban-rural income gap increases by 1.3 percentage points.

Impact on ecological benefits. The degree of integration of the three industries shows a significant impact on green production, energy saving, and emission reduction, while the degree of industry chain extension has a relatively limited role in the enhancement of ecological benefits, mainly focusing on the promotion of clean production and resource recycling.

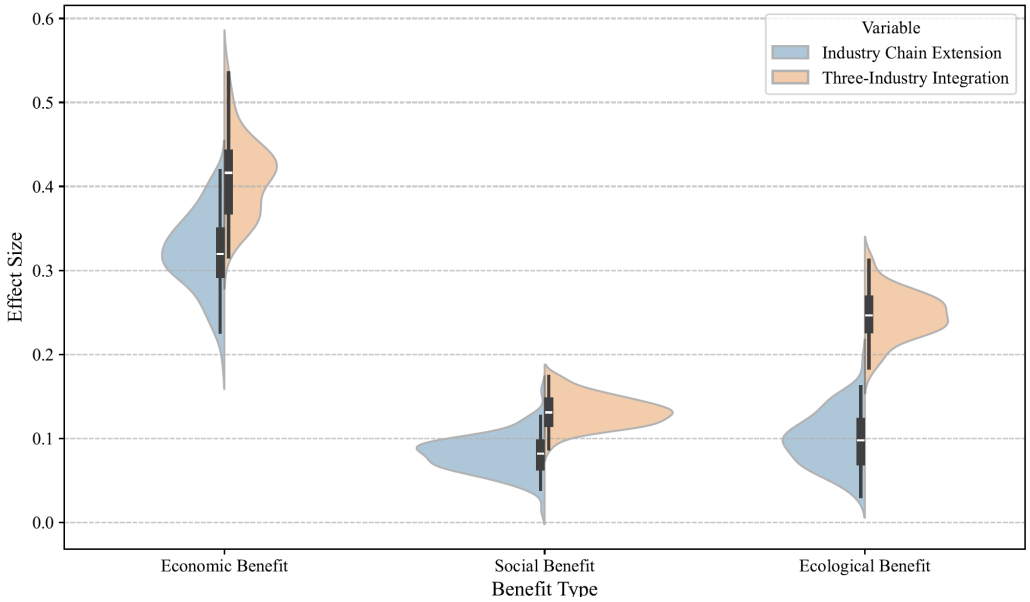

Figure 5. Extension of industrial chains and integration of the Three Sectors yield three distinct types of benefits

Case Analysis

Combining the typical cases of Xinxiang, Anyang, and Nanyang, given that these regions are part of the panel data, the case analysis here is not intended for independent statistical validation, but rather to exemplify and interpret the specific practical paths and micro-mechanisms behind the quantitative findings. In the Xinxiang case, relying on large textile enterprises and national industrial parks, Xinxiang has formed a complete industrial chain from cotton planting to spinning, weaving, dyeing, and clothing, and through the combination with e-commerce, logistics, and tourism industries, the synergistic effect index reaches the highest level in the province. In the case of Anyang, it focuses on the development of cotton by-product processing, such as cottonseed oil and cottonseed protein, to realize the deep integration of primary and secondary industries in agriculture, and combines it with local culture and tourism to promote the sustainable increase of farmers' income. In the Nanyang case, by organizing the Cotton Culture Festival and developing rural tourism, a three-

in-one integration model of agriculture, industry, and services has been formed, and the urban-rural income gap has been narrowed to a level significantly higher than the provincial average.

DISCUSSION

Synthesizing the above results, the following discussions can be drawn: first, the extension of the cotton textile industry chain in Henan and the integration of the three industries in agriculture have formed a benign interactive relationship. The vertical extension of the industrial chain provides a solid foundation for the integration of the three industries, while the integration of the three industries in turn promotes the value extension of the industrial chain. Secondly, the enhancement of synergistic effect is not only reflected in economic benefits, but also prominent in social and ecological benefits. In particular, the integration of the three industries plays a key role in promoting the coordinated development of urban and rural areas and green transformation. Third, there are obvious differences in synergistic effects among different regions. Industrial cluster regions such as Xinxiang, Anyang, and Nanyang have entered a higher level of coordination, while some county regions are still at a low to medium level, indicating that policy support and industrial organization innovation are decisive in synergistic development. Fourth, the regression results verify the validity of the research framework and indicator system constructed in the previous period. The extension of the industrial chain and the integration of three industries show significant impacts on economic, social, and ecological benefits, and the marginal effect of the integration of three industries is more prominent in some areas. This indicates that promoting the high-quality development of Henan's cotton textile industry needs to pay more attention to the integration with the tertiary industry while continuing to extend the industrial chain.

CONCLUSION

This study systematically examined the synergistic relationship between the extension of Henan’s cotton textile industrial chain and the integration of primary, secondary, and tertiary agricultural industries. By constructing an index system and applying the entropy value method, the coupling coordination model, and panel regression analysis, the research demonstrated that both chain extension and industry integration have shown steady improvement from 2014 to 2024. The synergy index rose from 0.28 to 0.61, confirming a shift toward a benign interactive stage. Empirical results highlighted that these developments significantly

enhanced farmers' income, expanded employment opportunities, reduced the urban–rural income gap, and promoted green transformation. Regional cases, such as Xinxiang, Anyang, and Nanyang, further validated the benefits of industrial clustering and innovation in achieving higher synergy levels.

Despite its contributions, this study has several limitations. First, the indicator system, while comprehensive, lacks sufficient dynamism and foresight, limiting its ability to capture rapid changes in the global textile value chain. Second, case studies focused mainly on a few leading regions, which may not fully represent the diversity of development paths across the province. Third, the analysis relied primarily on macro-level data, with insufficient attention to micro-level mechanisms such as enterprise innovation strategies, farmer participation, and government-industry linkages.

Future research should incorporate micro-level data from enterprises, cooperatives, and households to better capture the mechanisms of collaboration and innovation. Greater emphasis should also be placed on analyzing Henan's cotton textile industry within the context of global supply chain restructuring, digital transformation, and smart manufacturing. Moreover, comparative studies across provinces and international cases could provide broader insights, while dynamic and predictive evaluation models should be developed to enhance the forward-looking value of research. These efforts will support the design of more targeted policies and innovative strategies to further strengthen the synergistic development of the cotton textile industry and agricultural economy.

Author Contributions

Yujie Wang contributes to conceptualization, methodology, formal analysis –investigation, resources, writing-original draft preparation; writing-review and editing, visualization.

Conflicts of Interest

The author declares no conflict of interest.

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Human Research Subjects

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