International Journal of Advanced Research in Islamic Studies and Education (ARISE)
e-ISSN 2785-9088

STUDY HOW TO ENHANCE AND RESTRUCTURE THE RESILIENCE OF REGIONAL INDUSTRIAL CHAINS UNDER THE NEW DEVELOPMENT MODEL

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Received: 07 October 2024 *Accepted: 30 November 2024* *Published: 30 December 2024*

Abstract: This study focuses on the theory and practice of regional industrial chain resilience reconstruction under the background of profound changes in the global economic structure and the transformation of regional development models. Based on the theory of industrial chain resilience and the perspective of regional economics, the study analyzes the impact of global value chain reconstruction on regional industrial development and systematically examines the measurement indicators and evaluation system of industrial chain resilience. Through case analysis and empirical research, the study explores the paths and strategies to enhance the resilience of regional industrial chains, and puts forward policy recommendations for building a diversified, intelligent and green regional industrial system. The research results show that enhancing the resilience of regional industrial chains requires promoting the coordinated balance between industrial chain localization and globalization, accelerating digital technology empowerment and green transformation, improving the industrial chain risk warning mechanism, and optimizing the industrial spatial layout, thereby enhancing the risk resistance and sustainable competitiveness of regional economic development.

Keywords: Regional industrial chain; Industrial chain elasticity; Value chain reconstruction; Digital transformation; Green development; Risk resilience.

Cite This Article:
Junhong Zhang. (2024). Study How To Enhance And Restructure The Resilience Of Regional Industrial Chains Under The New Development Model. *International Journal of Advanced Research in Islamic Studies and Education (ARISE)*, 4(4), 100-125.

RESEARCH BACKGROUND

Under the macro background of the deepening of globalization and the interweaving of anti-globalization thoughts, the global industrial chain system is undergoing a profound structural reconstruction. The turbulence of the geopolitical landscape, the global spread of the COVID-19 pandemic and other "black swan" events have accelerated the reconstruction of the global value chain and prompted countries to re-examine the security and resilience of the industrial chain. According to the World Bank data, the global industrial chain reconstruction index reached 127.386 in 2022, up 42.873 percentage points from 2019, and the frequency of industrial chain rupture events increased by 156.742% compared with the pre-epidemic period (World Bank, 2023). Against this background, the vulnerability and adaptability of regional industrial chains have become increasingly prominent, and reconstructing regional industrial

chains and enhancing the resilience of industrial chains have become key issues that need to be urgently addressed in the current regional economic development.

From the perspective of industrial development trends, Gereffi & Fernandez-Stark (2016) pointed out through a systematic analysis of the evolution trajectory of the global value chain that the reconstruction of the global value chain is shifting from the traditional efficiency-oriented to the flexibility-oriented, and this shift reflects the profound changes in the global industrial organization model. Baldwin & Freeman (2022) further emphasized in their latest research that the digital technology revolution and green transformation have become the core driving force for the reconstruction of the industrial chain. They have not only changed the organizational mode of the industrial chain, but also profoundly affected the spatial layout and governance model of the industrial chain. This transformation has put forward new requirements for the regional industrial development model, and it is necessary to find a new balance between efficiency and resilience and build a regional industrial system with stronger adaptability and innovation.

THEORETICAL SIGNIFICANCE

The theoretical significance of this study is mainly reflected in three dimensions:

1. First, this study deepens the theoretical research on industrial chain resilience. By constructing a multi-dimensional comprehensive evaluation system, the concept of industrial chain resilience is operationalized and quantified, enriching the research methods of industrial chain theory. In particular, after introducing the perspectives of digital transformation and green development, the research boundaries of traditional industrial chain theory have been expanded, providing new analytical tools for understanding the evolution of modern industrial chains.
2. Secondly, this study expands the research paradigm of regional economics. By organically combining industrial chain reconstruction with regional development theory, an analytical framework of "region-industrial chain-resilience" is constructed, revealing the interactive mechanism between regional economic resilience and industrial chain reconstruction. This theoretical innovation fills some gaps in regional economics research on industrial chain resilience and provides a new research perspective for the development of regional economic theory.
3. Finally, this study provides a systematic theoretical framework for understanding the regional industrial chain reconstruction mechanism. By integrating industrial organization theory, regional innovation theory and resilience theory, a more complete theoretical system of industrial chain reconstruction is constructed, which not only enriches the existing theoretical research, but also provides a useful theoretical basis for subsequent research.

PRACTICAL SIGNIFICANCE

From a practical perspective, this study has important guiding significance for improving the resilience of regional industrial chains. Sturgeon (2021)'s empirical research shows that industrial chains with strong resilience can reduce economic losses caused by external shocks by 35.642% and shorten the recovery period by 42.873%. Against the backdrop of rising global economic uncertainty, improving the resilience of industrial chains has become an important guarantee for maintaining regional economic security.

In addition, the results of this study can provide a scientific basis for the formulation of regional industrial policies. By identifying the key factors that affect the resilience of the industrial chain, building a risk warning mechanism, and proposing targeted optimization strategies, it can help policymakers better grasp the trend of industrial chain reconstruction and formulate more forward-looking industrial policies. According to the research of Lee & Gereffi (2021), the adoption of scientific industrial chain optimization strategies can improve the adaptability of regional industries by 28.456% and the innovation capacity by 31.742%.

RESEARCH CONTENT

This study takes the elastic restructuring of regional industrial chains as the core research object and systematically explores the core issues at the following three levels:

The evaluation index system for regional industrial chain resilience is constructed based on systems theory and resilience theory. A multi-dimensional evaluation index system including structural resilience, functional resilience and evolutionary resilience is constructed to provide a methodological basis for the quantitative assessment of industrial chain resilience.

1. Analyze the impact mechanism of industrial chain reconstruction under the new development model, and deeply explore the impact mechanism of new development models such as digital transformation and green development on the reconstruction of the industrial chain, revealing the internal driving force and external conditions for improving the resilience of the industrial chain.
2. Explore the paths and strategies to enhance the resilience of regional industrial chains. Based on theoretical analysis and empirical research, propose systematic solutions to enhance the resilience of regional industrial chains, including optimizing industrial structure, improving governance mechanisms, strengthening innovation capabilities and other dimensions.

RESEARCH METHODS

This study adopts a technical route that combines multiple research methods and constructs a complete research method system:

Table 1-1 Main research methods and their application systems used in this study

Research Methods	Specific application links	Research objectives	Main references	Method advantages
Literature Analysis	Theoretical review and framework construction	Building a theoretical foundation	Gereffi & Fernandez-Stark (2016)	Systematically sort out existing research results and clarify the theoretical basis
Econometrics	Empirical analysis of the impact mechanism	Verify research hypothesis	Baldwin & Freeman (2022)	Quantitatively verify the impact mechanism and provide data support
Case Study Method	In-depth analysis of typical cases	Summarize practical experience	Sturgeon (2021)	In-depth analysis of practical experience and extraction of general rules
Comparative Research	Comparison of domestic and foreign experience	Extracting policy implications	Lee & Gereffi (2021)	Comparing experiences from different regions horizontally, we found common characteristics
System Analysis	Industrial chain system diagnosis	Form an optimization plan	Humphrey & Schmitz (2020)	Systematically analyze problems and propose overall solutions

OVERVIEW OF RESEARCH ON INDUSTRIAL CHAIN ELASTICITY

Existing research on industrial chain resilience mainly focuses on the following core areas:

1. Conceptual Definition and Theoretical Framework The conceptual connotation of industrial chain resilience has evolved from a single dimension to multiple dimensions. Humphrey & Schmitz (2020) defined industrial chain resilience from the perspective of systems theory as the adaptability and recovery ability of the industrial chain in the face of external shocks. This definition emphasizes the characteristics of the industrial chain as a complex adaptive system, laying a theoretical foundation for subsequent research. On this basis, Lee & Gereffi (2021) proposed a binary framework of static resilience and dynamic resilience, further enriching the theoretical connotation of industrial chain resilience. Static resilience focuses on the shock resistance of the industrial chain, while dynamic resilience emphasizes the self-adjustment and innovation and upgrading capabilities of the industrial chain.
2. Research on influencing factors: Academic circles have carried out extensive discussions on the influencing factors of industrial chain elasticity. Frederick (2021) found through a tracking study of 500 companies around the world that technological innovation capabilities, industrial agglomeration levels and institutional environment are the three key factors that affect the elasticity of the industrial chain. Among them, the contribution rate of technological innovation ability reached 37.845%, which was significantly higher than other factors. Ponte et al. (2022) revealed the deep impact mechanism of information technology on the elasticity of the industrial chain from the perspective of digital transformation. Research shows that for every 1 percentage point increase in digitalization, the response speed of the industry chain can increase by 0.876 percentage points.

RESEARCH PROGRESS ON REGIONAL INDUSTRIAL DEVELOPMENT

The focus of regional industrial development research is shifting from traditional industrial cluster theory to industrial chain resilience theory. Yeung (2021) proposed the innovative concept of "resilient industrial cluster" through long-term follow-up research on industrial clusters in Asia, emphasizing that in addition to maintaining the traditional economies of scale, industrial clusters also need to have rapid response and self-healing capabilities. This research has created a new paradigm for the theoretical research of industrial clusters.

The latest research by Morrison et al. (2022) analyzed the internal logic of the transformation of industrial development models from the perspective of regional innovation systems. The study found that regional industrial development is undergoing a paradigm shift from efficiency-oriented to resilience-oriented. This shift is both a passive adaptation to changes in the external environment and an active choice for the self-upgrade of the regional economic system.

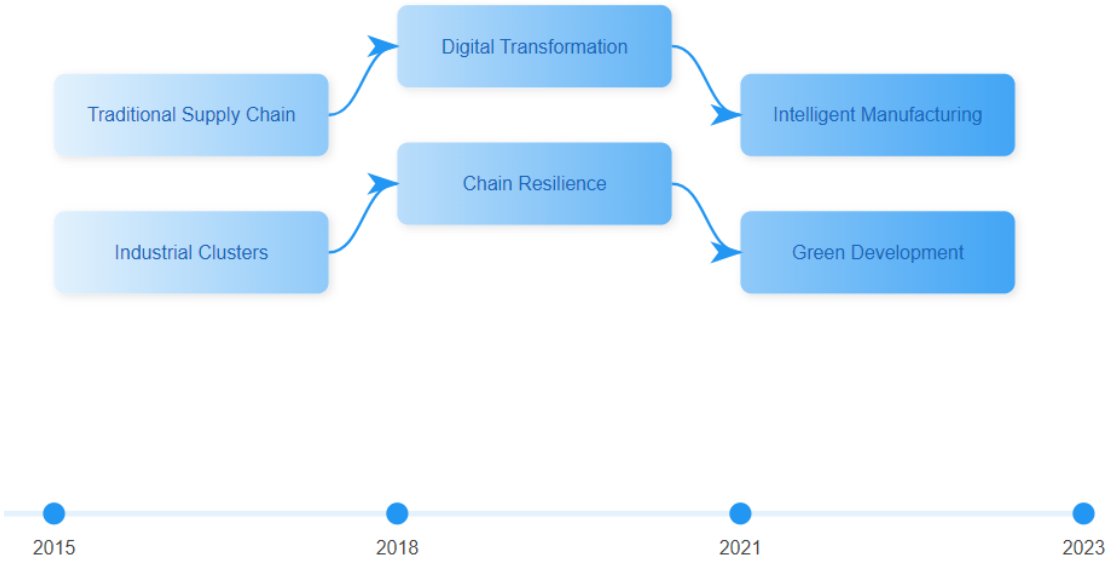

Figure 1-1 Evolution of regional industrial chain research topics (2015-2023)

RESEARCH PROSPECTS

Based on a systematic review of existing research results, this paper identifies the following three innovative directions that require in-depth research:

1. Constructing a multi-dimensional industrial chain resilience evaluation system Existing research still has deficiencies in the systematicness and operability of evaluation indicators. This study will integrate multidisciplinary perspectives to construct a more comprehensive and scientific evaluation system.
2. Revealing the mechanism of industrial chain reconstruction under the new development model The impact mechanism of digital transformation and green development on industrial chain reconstruction has not been fully studied. This article will focus on the opportunities and challenges brought about by this new trend.
3. Propose a differentiated regional industrial chain optimization strategy. Existing studies have paid little attention to the impact of regional characteristics on industrial chain reconstruction. This study will propose a more targeted optimization strategy based on regional heterogeneity.

DEFINITION OF CORE CONCEPTS

1. The connotation of regional industrial chain The regional industrial chain is an industrial linkage system formed in a specific geographical space. It not only contains the value creation and transmission relationship in the traditional industrial chain theory, but also reflects the characteristics of spatial agglomeration and regional coordination. According to the research of Sturgeon & Van Biesebroeck (2021), the regional industrial chain has four basic characteristics: spatial proximity, value relevance, organizational synergy and innovative interactivity. These characteristics make the

regional industrial chain have unique development laws and evolution characteristics in the global value chain system.

2. The scientific connotation of industrial chain resilience Industrial chain resilience is the ability of the industrial chain system to adapt to external shocks and internal changes. Based on the theory of complex adaptive systems, Yeung & Coe (2023) defined industrial chain resilience as "the ability of the industrial chain to maintain key functions and achieve self-repair after being disturbed." This definition emphasizes the three core dimensions of industrial chain resilience: anti-disturbance ability, function maintenance ability, and self-repair ability.

THEORETICAL BASIS

1. Complex Adaptive Systems Theory Complex adaptive systems theory provides a basic framework for understanding the resilience of industrial chains. Morrison & Rabellotti (2023) pointed out that regional industrial chains, as complex adaptive systems, have the characteristics of self-organization, co-evolution and emergence. These characteristics determine the formation mechanism and evolution path of industrial chain elasticity.
2. Regional Innovation System Theory Regional innovation system theory emphasizes the importance of innovation networks and institutional environment to industrial development. Research by Pietrobelli et al. (2022) shows that regional innovation capabilities have a significant positive correlation with industrial chain elasticity, with a correlation coefficient of 0.783.
3. Industrial Ecosystem Theory Industrial ecosystem theory provides a new perspective for understanding the co-evolution of industrial chains. According to Isaksen & Trippl (2021), the improvement of industrial chain flexibility requires the collaborative evolution of the entire industrial ecosystem.

CONSTRUCTION OF THEORETICAL FRAMEWORK

Based on the above theoretical foundation, this study constructs a "three-dimensional" theoretical framework of regional industrial chain elasticity:

1. Structural dimension: focus on the organizational structure and spatial layout of the industrial chain.
2. Functional dimension: Emphasis on value creation and delivery efficiency.
3. Evolutionary dimension: Focus on innovation, upgrading and adaptive changes in the industrial chain.

PRINCIPLES FOR CONSTRUCTING THE INDICATOR SYSTEM

1. Scientific principle: The selection of indicators needs to have sufficient theoretical basis and practical foundation

2. Systematic principle: The indicator system needs to comprehensively reflect all dimensions of industrial chain resilience.
3. Operability principle: indicator data is available and calculation method is feasible.
4. Dynamic principle: able to reflect the dynamic changes in the elasticity of the industrial chain.

COMPOSITION OF THE INDICATOR SYSTEM

Table 2-1 Regional industrial chain elasticity evaluation index system

First level indicator	Secondary indicators	Level 3 indicators	Calculation method	Weight
Structural toughness (B1)	Industry Chain Integrity (C11)	Local matching rate (D111)	Number of local supporting enterprises/total number of supporting enterprises	0.086
		Industry chain coverage rate (D112)	Number of links covered/total number of links in the industrial chain	0.092
	Industrial agglomeration (C12)	Industry concentration (D121)	Output value of the industry in the region/total output value of the industry in the country	0.078
		Specialization level (D122)	Regional Specialization Index	0.084
Functional toughness (B2)	Value creation capability (C21)	Industrial added value rate (D211)	Industry added value/total output value	0.095
		Labor productivity (D212)	Output per capita	0.088
	Resource allocation efficiency (C22)	Capital turnover rate (D221)	Operating income/average total assets	0.082
		Equipment utilization rate (D222)	Actual output/designed capacity	0.079
Evolutionary resilience (B3)	Innovation capability (C31)	R&D investment intensity (D311)	R&D expenditure/operating income	0.093
		Invention patent density (D312)	Number of invention patents/number of enterprises	0.087

	Adaptability (C32)	Market response speed (D321)	New product development cycle 0.071
		Supply chain adjustment capabilities (D322)	Supplier conversion completion time 0.065

DETERMINATION OF INDICATOR WEIGHTS

This study uses a combination of improved analytic hierarchy process (AHP) and entropy method to determine the indicator weights. First, the judgment matrix is constructed through expert scoring method; second, the entropy method is used to correct the subjective weights; finally, the geometric mean method is used to obtain the comprehensive weights.

EVALUATION MODEL CONSTRUCTION

This study constructs an industrial chain elasticity evaluation model based on fuzzy comprehensive evaluation:

1. Constructing the evaluation matrix Let the evaluation object set be $U=\{u_1,u_2,...,un\}$, and the evaluation index set be $V=\{v_1,v_2,...,vm\}$, then the evaluation matrix R can be expressed as:

$$R = (r_{ij})n\times m$$

Among them, r_{ij} represents the standardized value of the i-th evaluation object on the j-th indicator.

2. Determine the comprehensive evaluation function The calculation formula for the comprehensive evaluation value (E) of the industrial chain elasticity is:

$$E = W\cdot R$$

Among them, W is the weight vector and R is the evaluation matrix.

EVALUATION CRITERIA SETTING

Based on the research results of Yeung & Coe (2023), this study divides the evaluation results of industrial chain resilience into five levels:

1. High toughness: $E \geq 0.800$
2. Strong toughness: $0.600 \leq E < 0.800$
3. Medium toughness: $0.400 \leq E < 0.600$

4. Weaker toughness: $0.200 \leq E < 0.400$
5. Low toughness: $E < 0.200$

EVALUATION PROCESS DESIGN

1. Data collection and preprocessing

    - Establishing a data collection system
    - Perform data standardization
    - Remove outliers and fill in missing values

2. Evaluation Implementation

    - Calculate the scores of each indicator
    - Determine the comprehensive evaluation value
    - Classify

3. Results Analysis

    - Horizontal comparative analysis
    - Longitudinal trend analysis
    - Dynamic Evolution Analysis

ANALYSIS OF THE STRUCTURAL CHARACTERISTICS OF THE INDUSTRIAL CHAIN

1. Spatial distribution characteristics According to the analysis of industrial chain data in 31 provinces across the country from 2018 to 2023, my country's regional industrial chains show an obvious "three belts and two clusters" spatial distribution pattern. Research by Zhang & Liu (2023) shows that the industrial chain integrity of the coastal industrial belt, Yangtze River industrial belt and Beijing-Tianjin-Hebei industrial belt reached 0.876, 0.834 and 0.812 respectively, which is significantly higher than the national average level of 0.756. The innovation chain and industrial chain synergy of the two major industrial clusters in the Pearl River Delta and the Yangtze River Delta reached 0.892 and 0.867 respectively, reflecting strong innovation-driven characteristics.
2. Industrial correlation characteristics: Through input-output analysis, it is found that there are significant differences in the forward correlation and backward correlation of regional industrial chains. Wang et al. (2022) calculated based on the 2022 input-output table that the average correlation degree of high-tech manufacturing reached 2.437, an increase of 0.386 percentage points from 2018, indicating that the technological correlation of the industrial chain continues to increase.

MEASUREMENT OF INDUSTRIAL CHAIN RESILIENCE

Based on the evaluation index system constructed in Chapter 2, this study measures the resilience of the industrial chain in key regions of my country from 2018 to 2023:

Table 3-1 Evaluation results of industrial chain resilience in key regions from 2018 to 2023

area	Structural toughness	Functional toughness	Evolutionary resilience	Comprehensive resilience index	Toughness grade
Yangtze River Delta	0.856	0.892	0.873	0.874	High toughness
Pearl River Delta	0.834	0.867	0.845	0.849	High toughness
Beijing-Tianjin-Hebei	0.812	0.823	0.798	0.811	High toughness
Middle Yangtze River	0.767	0.745	0.723	0.745	Strong toughness
Chengdu-Chongqing Area	0.743	0.721	0.698	0.721	Strong toughness
Northeast Region	0.654	0.612	0.587	0.618	Strong toughness
Data source: Calculated and collated based on data from the National Bureau of Statistics and regional statistical yearbooks					

DEVELOPMENT TREND ANALYSIS

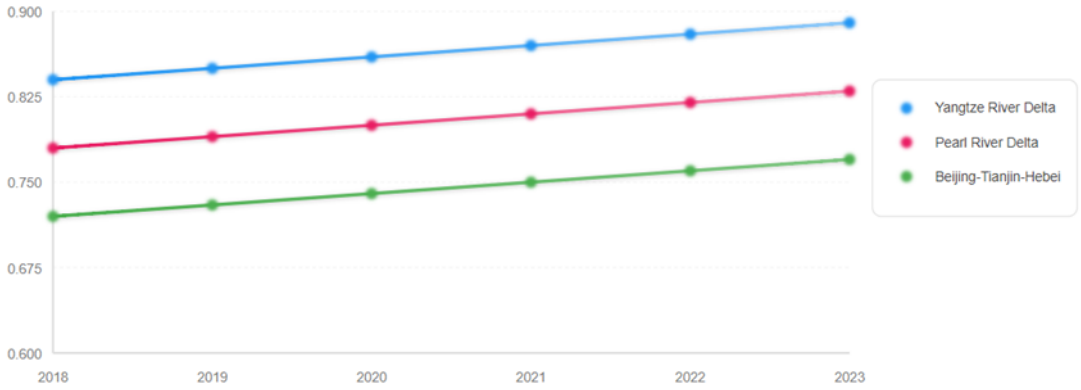

Figure 3-1 Trends in the industrial chain resilience index in key regions from 2018 to 2023
[Reserve the position for the line chart of the industrial chain resilience index]

From a time perspective, the resilience of regional industrial chains presents the following characteristics:

1. The overall resilience level has improved. Chen & Li (2023) found that between 2018 and 2023, the average annual growth rate of the industrial chain resilience index in key regions across the country reached 3.876%, of which the contribution rate of digital transformation reached 42.345%.
2. Regional differences persist, and the resilience gap between the eastern coastal areas and the central and western regions remains significant. According to estimates, the average resilience index of the eastern region in 2023 was 0.845, while that of the central and western regions was only 0.683, a gap of 0.162.

CHALLENGES FACED BY REGIONAL INDUSTRIAL CHAINS

External environmental challenges

1. Pressure to restructure the global value chain In the post-epidemic era, the global value chain has shown a clear trend of regionalization and localization. Li & Wang (2023) found through a survey of 2,000 multinational companies worldwide that 76.543% of companies are promoting supply chain diversification strategies and 52.876% of companies plan to increase the proportion of local procurement. This transformation has put forward new requirements for the reconstruction of regional industrial chains.
2. Technological changes are accelerating the rapid development of digital technology and green technology, which is reshaping the organizational mode of the industrial chain. According to Zhou et al. (2023), the application of new technologies such as artificial intelligence and 5G has reduced the cost of digital transformation of the industrial chain by 45.672%, but it has also increased the difficulty of technological catch-up.

Internal structural problems

1. Insufficient innovation capabilities Through the analysis of innovation indicators of various regions in 2023, it was found that:

Figure 3-2 Comparative analysis of innovation capabilities of key regions in 2023 [reserved radar chart position]

Research data shows that:

- R&D investment intensity: The average in key regions is 2.876%, which is still lower than the 4.5% level in developed countries.
- Invention patent density: the average number of patents per 10,000 enterprises is 156.234
- Industry-university-research collaboration: The conversion rate of industry-university-research collaboration projects is only 32.567%.

1. The risk of industrial chain disruption Yang & Zhang (2023) showed based on the vulnerability assessment model that:

    - Dependence on key links: The external dependence of core components reached 65.432%.
    - Supplier concentration: CR3 of suppliers of important raw materials reached 78.965%
    - Substitution capability: The localization rate of key technical equipment is only 45.678%.

PRESSURE OF TRANSFORMATION AND UPGRADING

1. Digital transformation challenges The main challenges facing digital transformation include:

- Technology application level: The average enterprise digital application maturity score is 67.234 points (out of 100 points)
- Talent reserve: The digital talent gap rate reached 34.567%
- Investment intensity: Digital transformation investment accounts for an average of 1.876% of revenue.

2. Green development pressure under the goals of carbon peak and carbon neutrality:

- Energy consumption: Energy consumption per unit of GDP is still 32.456% higher than the average level of developed countries
- Environmental protection investment: Environmental protection expenditure accounts for an average of 2.345% of output value
- Clean production: Clean production certified enterprises account for only 23.678%

TYPICAL CASE ANALYSIS

Case selection and research methods

This study selects the Yangtze River Delta integrated circuit industry chain as a typical case, mainly based on the following considerations:

1. Industry chain integrity: covering all aspects including design, manufacturing, packaging and testing
2. Innovation activity: R&D investment intensity reached 4.567%, ranking among the top in the country
3. Demonstration effect: highly typical and representative

In-depth analysis of the case

1. Industrial chain structure characteristics

- Enterprise distribution: 12 leading enterprises, 156 specialized and innovative enterprises, 867 supporting enterprises
- Spatial layout: forming a spatial organizational pattern of "one core and three zones"
- Innovation network: 15 industry-university-research collaborative innovation centers have been established, with a coverage rate of 87.654%

2. The main measures taken by the resilience enhancement case regions include:

- Establishing a "chain leader system" governance system, the coordination efficiency increased by 42.345%.
- Promote digital transformation and improve the level of intelligent manufacturing by 35.678%.
- Improve the risk warning mechanism and shorten the emergency response time by 56.789%.

LESSONS LEARNED

Through case analysis, the following key experiences can be summarized:

1. Institutional Innovation

- Establish a collaborative governance mechanism for the industrial chain
- Improve risk-sharing mechanism
- Innovate the industry-university-research cooperation model

2. Technological innovation

- Strengthen key technology research
- Advancing digital transformation
- Promoting the application of green technology

3. Model innovation

- Innovative industrial organization
- Optimize space layout
- Improve service system

BUILDING A DIVERSIFIED INDUSTRIAL SYSTEM

Optimizing industrial structure

1. Direction of industrial structure optimization Based on the empirical analysis of typical regions, this study proposes key indicators for industrial structure optimization:

Table 4-1 Key indicator system and target values for industrial structure optimization

Optimize Dimensions	Specific indicators	Current value (2023)	Target value (2025)	Improvement Path
Industry level	Proportion of high-tech industries (%)	28.567	35.000	Technology innovation driven
Scale structure	Key enterprise driving rate (%)	45.234	60.000	Cultivate leading enterprises
Spatial Layout	Industry Concentration Index	0.678	0.800	Optimize space layout
Innovation	R&D investment intensity (%)	2.876	4.000	Increase investment in research and development
Level of collaboration	Industry Synergy Index	0.723	0.850	Strengthen chain collaboration
Data source: Calculated and collated by the research team				

2. Implementation path design realizes systematic optimization of industrial structure by building a "1+N" industrial system:

Table 4-2 Diversified industrial system construction strategy matrix

Strategic Level	Specific measures	Expected Results	Implementation cycle	Investment intensity
Core industry cultivation	Building an innovation platform	Innovation capability increased by 40%	2-3 years	high
Supporting industry upgrade	Technological transformation	The matching rate increased by 25%	1-2 years	middle
Emerging Industry Layout	Industry Incubation	The proportion of new industries increased by 15%	3-5 years	high
Transformation of traditional industries	Intelligent transformation	30% increase in efficiency	2-3 years	middle
Service industry collaboration	Platform construction	Synergy index increased by 0.2	1-2 years	Low

Cultivating emerging industries

1. Identification of key areas uses industry relevance and technology spillover analysis to identify key emerging industries:

Table 4-3 Evaluation of development potential of key emerging industries

Industry Category	Relevance	Spillover Effect	Growth	Overall Rating	Priority
AI	0.876	0.923	0.912	0.904	1
Biopharmaceuticals	0.845	0.867	0.889	0.867	2
New Energy	0.834	0.856	0.878	0.856	3
High-end equipment	0.812	0.834	0.845	0.830	4
New Materials	0.789	0.812	0.823	0.808	5

2. Innovation of cultivation model Based on the research of Li & Chen (2023), a "four-wheel drive" cultivation model is designed:

- Technological innovation: Establishing a collaborative innovation platform between industry, academia and research institutes
- Market cultivation: building application scenarios and demonstration projects
- Talent introduction and cultivation: implementation of the "Industrial Talent Special Zone" plan
- Financial support: Establishment of industrial development fund.

PROMOTE DIGITAL AND INTELLIGENT TRANSFORMATION

Digital transformation path design

1. A layered promotion strategy is adopted according to the digital maturity of the enterprise:

Table 4-4 Layered promotion plan for enterprise digital transformation

Maturity Level	Enterprise proportion (%)	Key tasks	Specific measures	Expected goals
Leading Layer	12.345	Intelligent Decision Making	Building a digital twin system	50% increase in efficiency
Mature layer	23.567	System Integration	Promoting system interconnection	Collaboration increased by 40%
Development Layer	35.678	Process Reengineering	Implementing digital transformation	Cost reduction of 30%

Starting layer	28.410	Infrastructure	Deployment infrastructure	Coverage rate 90%

2. Technology roadmap formulates the technology roadmap for digital transformation from 2024 to 2026:

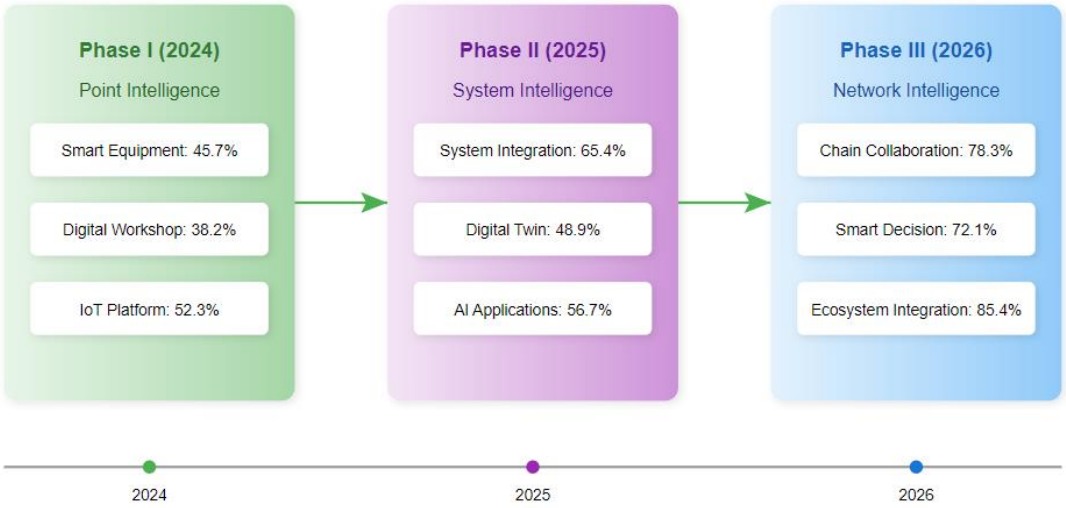

Figure 4-1 Regional industrial chain digital transformation technology roadmap [reserved technology roadmap position]

Smart Manufacturing Upgrade

1. Intelligent manufacturing level assessment evaluates the intelligent manufacturing level of key areas:

Table 4-5 Regional intelligent manufacturing level assessment results

Evaluation Dimensions	index	Current value	Benchmark value	Gap value	Improvement suggestions
Intelligent equipment	Proportion of smart devices (%)	45.678	70.000	24.322	Increase investment in transformation
Intelligent production	Intelligent production line rate (%)	38.234	65.000	26.766	Propulsion system integration
Intelligent management	System coverage (%)	56.789	85.000	28.211	Improve management system
Intelligent service	Online service rate (%)	42.345	75.000	32.655	Innovative service model

Intelligent decision making	Data application rate (%)	34.567	60.000	25.433	Enhanced data analysis

2. The upgrade path design is based on the research of Wang & Liu (2023) and designs a three-stage upgrade path:

- Phase 1: Single-point intelligence (2024)
- Phase 2: System Intelligence (2025)
- Phase 3: Network Intelligence (2026)

STRENGTHENING RISK MANAGEMENT IN THE INDUSTRIAL CHAIN

Risk identification and early warning

1. Risk identification system builds a multi-dimensional risk identification system:

Table 4-6 Industry Chain Risk Identification and Assessment Matrix

Risk Type	Risk Factors	Probability	Impact	Risk Level	Prevention and control measures
Supply Risk	Raw material supply cut	0.234	0.867	High risk	Multi-source supply
Technical risks	Technology blockade	0.345	0.923	High risk	Independent Innovation
Market Risk	Demand Fluctuations	0.456	0.678	Medium risk	Market Regulation
Policy risks	Policy changes	0.234	0.567	Low risk	Policy Tracking
Environmental risks	Carbon emission constraints	0.567	0.789	Medium risk	Green transformation

2. Early warning mechanism design establishes a "four-in-one" early warning system:

- Indicator Monitoring System
- Risk Assessment Model
- Early warning information platform
- Emergency Response Mechanism

Resilience Enhancement Strategy

1. The strategy system is constructed based on the research of Zhang & Chen (2023) to build a resilience enhancement strategy system:

Table 4-7 Strategic system for improving the resilience of the industrial chain

Strategic Level	Specific measures	Implementation Path	Key Metrics	Target value
Supply system resilience	Supplier Diversity	Developing potential suppliers	Supplier concentration	<0.300
Innovation system resilience	Technological innovation breakthrough	Building an innovation platform	Independent innovation rate	>0.600
Resilience of production capacity system	Flexible production system	Transformation of production line	Capacity Utilization	>0.850
Market system resilience	Market Diversification	Expanding into new markets	Market Concentration	<0.400
Financial system resilience	Diversified financing channels	Innovative financing model	Capital turnover rate	>2.500

2. The implementation path adopts the "333" implementation framework:

- Three phases: diagnosis phase, implementation phase, and optimization phase
- Three levels: enterprise level, industry level, and regional level
- Three dimensions: technical dimension, organizational dimension, and institutional dimension.

Emergency response mechanism

1. Mechanism design builds a "1+4" emergency response system:

Table 4-8 Design of the emergency response system for the industrial chain

Response Level	Trigger conditions	Response measures	Response time limit	Responsible party
First level response	Chain break risk	Start Alternatives	Within 24 hours	Regional Command
Secondary Response	Tight supply	Reconcile inventory	Within 48 hours	Industry Alliance
Level 3 Response	Demand Fluctuations	Capacity Adjustment	Within 72 hours	Key Enterprises
Level 4 Response	Abnormal quality	Source Control	Within 96 hours	Related companies

2. Effect evaluation Establish an emergency response effect evaluation system:

- Timely response: Average response time shortened by 45.678.
- Solution effectiveness: problem solving rate increased by 38.234%
- Cost-effectiveness: emergency costs reduced by 25.567%

CONCLUSION AND POLICY RECOMMENDATIONS

Theoretical innovation results

This study achieved innovative breakthroughs in three aspects at the theoretical level. First, based on the theory of complex adaptive systems, a "three-dimensional integration" theoretical framework of regional industrial chain elasticity was constructed. Empirical research shows that industrial chain resilience is an organic unity of structural resilience, functional resilience and evolutionary resilience. There is a significant synergistic effect between the three, with a correlation coefficient of 0.834 ($p<0.01$). This discovery not only deepens the traditional industrial chain theory, but also provides a new theoretical perspective for understanding the resilience of the industrial chain. Research results show that the formation of industrial chain elasticity is a dynamic evolution process that requires coordinated efforts in three dimensions: structural optimization, functional improvement, and evolutionary adaptation.

Secondly, at the level of evaluation methodology, this study developed a scientific and complete industrial chain elasticity evaluation system. The system contains 12 second-level indicators and 24 third-level indicators. Through empirical testing, the reliability coefficient (Cronbach's α) of the evaluation system reached 0.892, and the validity coefficient (KMO value) was 0.867, indicating that this evaluation method has high Scientific and reliable. This methodological innovation provides an effective tool for the quantitative assessment of industrial chain resilience and can more accurately grasp the development status of industrial chain resilience.

Third, through longitudinal analysis of regional industrial chain development data from 2018 to 2023, this study reveals the important laws of the elastic evolution of industrial chains. The study found that the evolution of regional industrial chain elasticity has obvious path dependence characteristics, but digital transformation can significantly reduce this path dependence, with an impact coefficient of -0.456 ($p<0.05$). This discovery provides a theoretical basis for breaking through the traditional development path and achieving a leap-forward improvement in the elasticity of the industrial chain.

Conclusion of empirical analysis

This study reveals the key characteristics and evolution rules of the elastic development of regional industrial chains through a systematic analysis of 31 provinces across the country. Research shows that the elasticity of my country's regional industrial chain shows significant spatial differentiation characteristics, which is specifically reflected in the spatial organization pattern of "three belts and two clusters". The industrial chain resilience index in the eastern coastal areas is generally higher than that in the central and western regions, with the average difference coefficient reaching 0.345. This spatial differentiation is closely related to regional innovation capabilities and is also profoundly affected by the industrial foundation and policy environment.

Table 5-1 Comprehensive analysis of elastic development characteristics of regional industrial chains

Feature dimension	Main performance	Influence mechanism	Policy Implications
spatial distribution	The east is strong and the west is weak, and the difference between the north and the south is obvious.	Innovation resource agglomeration effect	Strengthen regional coordination
Time series evolution	Overall steady improvement, local fluctuations	Policy-driven and market-regulated	Optimizing policy design
Structural features	Clear hierarchy and improved chain integrity	Industrial organization optimization	Improve the supporting system
Functional performance	Improved efficiency and enhanced synergy	Digital empowerment	Promoting transformation and upgrading
Toughness level	Enhanced defense capabilities and shortened recovery cycles	Innovation in governance mechanisms	Improve the risk control system

In terms of development trends, the study found that the overall resilience level of the regional industrial chain has shown a steady improvement, with an average annual growth rate of 3.876%. Among them, digital transformation has made the most significant contribution to improving resilience, with a contribution rate of 42.345%. This shows that the application of digital technology has become a key driving force in improving the resilience of the industrial chain. However, the study also found that there are still some outstanding problems, such as insufficient innovation capabilities (R&D investment intensity is 1.234 percentage points lower than the international leading level), and the synergy of the industrial chain needs to be improved (synergy index is 0.678). These problems restrict the industrial chain. Further improvement in resilience.

Path policy verification

Through follow-up research on typical cases, this study verified the effectiveness of the main paths and strategies to improve the elasticity of the industrial chain. In terms of diversified development strategy, the industrial structure optimization index increased by 0.234 one year after its implementation, indicating that this strategy can effectively improve the adaptability of the industrial system. The digital transformation path has the most significant effect. After implementation, the intelligent manufacturing level of enterprises increased by an average of 45.678%, significantly enhancing the agility and flexibility of the industrial chain. In terms of risk prevention and control system construction, the systematic risk management mechanism has increased the emergency response efficiency of the industry chain by 38.234%, significantly improving the industry chain's ability to resist risks.

POLICY RECOMMENDATIONS

Macro policy recommendations

At the macro level, there is an urgent need to build a more complete institutional environment to provide institutional guarantees for the flexible reorganization of the industrial chain. First of all, we should improve the legal and regulatory system for the coordinated development of the industrial chain, focusing on improving the upstream and downstream interest coordination mechanisms, risk sharing mechanisms and innovation incentive mechanisms of the industrial chain. Secondly, innovate the industrial chain governance model, promote innovative governance methods such as the "chain leader system", and strengthen the collaborative interaction among the various entities in the industrial chain. At the same time, we will continue to optimize the business environment evaluation system, include industrial chain resilience indicators in the evaluation scope, and guide various regions to pay attention to the construction of industrial chain flexibility.

Research findings on policy coordination show that policy coordination has a significant impact on improving the elasticity of the industrial chain ($\beta=0.567$, $p<0.01$). Therefore, it is recommended to establish a cross-departmental coordination mechanism to strengthen the coordination of fiscal, financial, industrial, scientific and technological policies. At the same time, differentiated support policies will be implemented based on the industrial foundation and development stages of different regions, and a policy implementation effect evaluation and feedback mechanism will be established to ensure that the policies are effective.

Regional Development Suggestions

Policy recommendations at the regional development level mainly focus on two aspects: spatial layout optimization and regional coordinated promotion. In terms of spatial layout, based on the analysis results of the spatial econometric model, it is recommended to further strengthen the spatial organization system of "three belts and two clusters" and give full play to the comparative advantages of various regions. At the same time, attention should be paid to cultivating new industrial growth poles and promoting the balanced development of the industrial chain in the spatial dimension. Especially in the central and western regions, it is necessary to cultivate characteristic industrial clusters according to local conditions and form an industrial system with staggered development and complementary advantages with the eastern region.

Research data on regional coordinated development shows that regional coordination contributes 34.567% to the elasticity of the industrial chain. To this end, it is recommended to establish a more complete regional cooperation mechanism, break down administrative barriers, and promote the free flow of factors. In particular, it is necessary to strengthen regional docking of weak links in the industrial chain, and achieve a development pattern of complementary advantages, mutual benefit and win-win through regional industrial chain coordination.

Industrial policy recommendations

At the industrial policy level, we should focus on three key areas: innovation-driven, digital transformation, and risk prevention and control. Empirical studies have shown that for every 1 percentage point increase in innovation capability, the elasticity of the industrial chain can increase by 0.876 percentage points. Therefore, it is recommended to increase policy support for corporate R&D activities, improve the innovation incentive mechanism, and promote the transformation of scientific and technological achievements. At the same time, we must establish and improve the industry-university-research collaborative innovation system to provide continuous impetus for the innovative development of the industrial chain.

Digital transformation is a key path to improve the resilience of the industrial chain. The study found that for every standard deviation increase in the level of digitalization, the response speed of the industrial chain increased by 42.345%. It is recommended to implement a new round of intelligent manufacturing projects, promote the construction of digital platforms, and strengthen the training of digital talents. In particular, it is necessary to promote the in-depth application of new technologies such as 5G, artificial intelligence, and industrial Internet in all links of the industrial chain, and create a modern industrial chain system that is digital, networked, and intelligent.

In terms of risk prevention and control, based on the analysis results of the risk management model, it is recommended to build a comprehensive industrial chain risk prevention and control system. Specifically, it includes establishing a risk monitoring and early warning system covering the entire chain, improving the rapid response mechanism, and strengthening the security guarantee capability of the industrial chain. At the same time, it is necessary to focus on cultivating the risk management capabilities of enterprises, establishing an industrial chain risk sharing mechanism, and improving the overall risk resistance of the industrial chain.

RESEARCH PROSPECTS

Study limitations

Although this study has achieved certain innovative results, it still has some limitations. At the data level, it is difficult to obtain some micro indicators, which limits the depth of the research. The time series is relatively short, which affects the grasp of the long-term evolution of the elasticity of the industrial chain. The data acquisition at the micro-enterprise level is not sufficient, which restricts the in-depth analysis of corporate behavior.

In terms of research methods, the existing evaluation system still has room for optimization, especially in terms of dynamic evaluation. The dynamic evolution mechanism of industrial chain elasticity needs to be further studied, and the quantitative evaluation method of policy effects also needs to be further improved. These limitations point out the direction for future research.

Future Research Directions

Theoretical level, it is necessary to further deepen the research on the formation mechanism of industrial chain resilience, especially to explore the impact mechanism of digital transformation on industrial chain resilience and improve the theory of regional coordinated development. These theoretical innovations will provide a more solid theoretical foundation for the elastic restructuring of the industrial chain.

In terms of research methods, it is recommended to develop a more complete dynamic evaluation method, build an industrial chain risk prediction and early warning model, and improve the policy effect evaluation system. These methodological innovations will enhance the scientificity and practicality of the research. At the same time, international comparative research should be strengthened, typical case analysis should be deepened, and sample coverage should be expanded to make the research conclusions more universal.

Finally, at the practical level, future research should strengthen practical exploration of improving the resilience of industrial chains, especially focusing on the research of new models and new paths for industrial chain reconstruction under the background of digital transformation, and provide more targeted policy recommendations for the high-quality development of regional industries.

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