

finance by calculating the Moran index, further established a spatial measurement model, and found that there was a significant spatial spillover effect in the development of local green finance, which played a positive role in promoting the development of green finance in the surrounding areas <sup>[2]</sup>.

Heo and Lee also came to the conclusion that the development of green finance can have a positive spillover effect on the development of renewable energy in the surrounding areas when they studied the relationship between green finance and renewable energy by building a spatial Dubin model <sup>[3]</sup>.

## **2.2. Research on the impact of green finance on the upgrading of industrial structure**

From the development process of green finance, its development model gradually tends to be green and environmentally friendly, focusing more on promoting the optimization and upgrading of industrial structure through resource allocation to achieve a win-win situation between economic development and environmental protection <sup>[4]</sup>. Green finance helps to optimize and adjust the industrial structure by innovating financial instruments and service modes, such as green credit and green bonds, and also brings new profit growth points to the financial industry <sup>[5]</sup>.

From the perspective of enterprises, green finance, through differentiated financial support, has effectively promoted traditional enterprises to accelerate the pace of technological innovation, so that enterprises can increase investment in green projects, thus realizing the upgrading of industrial structure. From the analysis of correlation degree, there are differences in the correlation degree between green credit and the three major industries, green credit is most closely related to the tertiary industry, and the primary industry is the smallest <sup>[6]</sup>. In addition, Palencia *et al.* used the double difference method to analyze the relationship between the construction of green finance “Experimental Zone” and the development of industrial structure by collecting and sorting out green finance policies as a quasi-natural experiment <sup>[7]</sup>. Peneder further confirmed the significant role of green finance in the upgrading of industrial structure through the application of grey correlation model in green finance and industrial structure upgrading <sup>[8]</sup>. At the same time, the establishment of financial reform pilot zones is also regarded as an effective means to promote the upgrading and rationalization of regional industrial structure <sup>[9]</sup>. Chengchao *et al.* found that green finance can actively guide enterprises to transform to green production mode, reduce dependence on and destruction of natural resources, and promote the vigorous development of the tertiary industry <sup>[10]</sup>.

## **3. Definition and related concepts**

### **3.1. Green finance**

Green finance is a market tool and financial instrument aimed at effectively addressing environmental issues, and this concept has been widely recognized in Western countries. The core mechanism of its operation lies in promoting environmental protection and sustainable development through the voluntary actions and self-discipline of financial institutions. Specifically, green finance encompasses various policies and guidelines, playing an important role in guiding the flow of funds towards green industries and promoting the research and application of environmentally friendly technologies. Pigouvian taxes, as an environmental and economic policy tool, effectively incentivize companies to reduce pollution emissions and improve resource utilization efficiency by levying taxes and fees related to environmental pollution, incorporating environmental costs into their production and consumption processes. In addition, the Equator Principles, as a voluntary guideline, require

financial institutions to fully consider environmental and social risks when financing projects. This reflects the proactive and responsible role of financial institutions and has become a sustainability standard widely followed by the international banking industry. The environmental equity trading market based on Coase Theorem also provides new opportunities for the development of green finance. For example, the carbon finance market allows companies to achieve emission reduction targets by buying and selling carbon emission rights, thereby optimizing the allocation of emission reduction costs and improving the efficiency of resource allocation. The application of this market mechanism provides enterprises with flexible and diverse emission reduction options. With the passage of time, these environmental financial instruments have been continuously expanded and improved, and their application scope has gradually expanded to more fields, ultimately forming a comprehensive green financial system covering multiple fields.

### **3.2. Upgrade of industrial structure**

The upgrading of industrial structure is a process involving the reconfiguration of production resources, with the core objective of promoting the evolution of industrial structure towards a more advanced and rational direction. This process is not just about adjusting the proportional relationship between the three major industries, but a profound transformation that touches on the foundation of the industry. Specifically, it manifests as the dominant industry gradually shifting from traditional industries with low added value, high consumption, and low technology to emerging industries with high added value, low consumption, and high technology. This transformation not only enhances the overall efficiency and competitiveness of the industry, but also marks a process of upgrading and rationalizing the industrial structure. During this process, resource allocation has been optimized and industrial structure has been upgraded, providing a solid foundation for the sustained and healthy development of the economy. In addition, the upgrading of industrial structure is also a dynamic process that continues to evolve with the continuous improvement of social productivity levels. During this process, the industrial development mode has shifted from extensive to intensive, and the development layout has shifted from scattered to clustered. This transformation not only brings significant improvements in production efficiency, but more importantly, it effectively promotes the agglomeration development and collaborative innovation of industries, injecting new vitality into enhancing industrial competitiveness.

Sustainable industrial structure refers to the principle of sustainable development that must be followed in the process of optimizing and upgrading industrial structure, taking into account economic benefits, social welfare, and ecological environment protection. Sustainable industrial structure is the process of traditional industrial structure evolving towards a green and environmentally friendly industrial system, aimed at breaking the bottleneck of resource and environmental constraints faced by economic development. With the development of green industrial structure, it is manifested in the gradual decline of traditional polluting industries and the rapid rise of emerging green environmental protection industries. Promoting sustainable development of industrial structure can not only solve the problem of heavy industrial structure in China, but also provide important support for achieving high-quality economic and social development.

## **4. Current situation and research**

### **4.1. Environmental status in Jiangsu province**

There are many urgent needs for the development of green finance in Jiangsu Province. In terms of the



environment, Jiangsu's industrial prosperity has led to pollution problems due to long-term extensive development, and there is an urgent need for green finance to guide funds to flow into the field of environmental protection, help solve pollution and restore ecology. From an economic perspective, the industrial structure urgently needs improvement. Green finance can promote the transformation of traditional high-energy consumption industries, cultivate new energy, environmental protection and other green industries, and add new impetus to economic growth. In terms of policy dimension, in response to the national green development strategy, Jiangsu province has used green finance to achieve the dual carbon goal and improve Jiangsu's position in the national green development pattern. Therefore, based on national policies, Jiangsu province has launched many policy measures to promote the development of green finance.

**Table 1** lists the unit wastewater and exhaust emissions in Jiangsu Province. It can be seen from the table that these two indicators gradually declined from 2014 to 2023, indicating that Jiangsu province has made significant achievements in energy conservation and emission reduction in recent years, and also suggesting that the scale of green finance development in Jiangsu province may continue to expand.

**Table 1.** Environmental indicators of Jiangsu province from 2014 to 2023

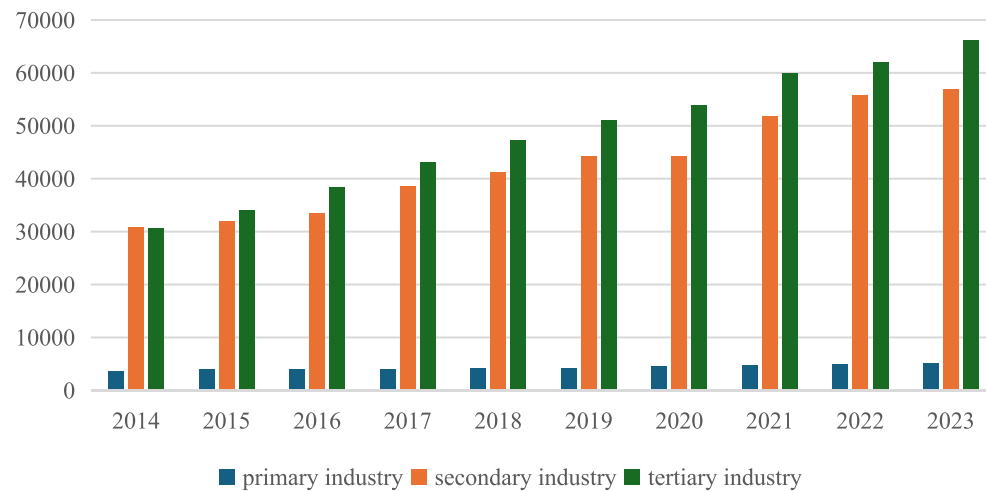
Year	Unit GDP industrial wastewater discharge (10000 tons/ billion yuan)	Unit GDP industrial waste gas emissions (ton/billion yuan)
2014	3.16	25.73
2015	2.90	20.91
2016	2.32	13.47
2017	1.77	9.33
2018	1.54	6.58
2019	1.39	4.79
2020	1.12	1.09
2021	1.04	0.75
2022	1.02	0.61
2023	0.97	0.54

## 4.2. Current situation of industrial structure in Jiangsu province

From **Figure 1**, it can be seen that since 2014, the industrial scale in Jiangsu has experienced significant growth, gradually expanding from 6508.832 billion yuan to 1282.2216 billion yuan. This growth indicates strong and sustained economic development momentum in the region. Over the past decade, the output value of the primary industry has grown slowly, gradually increasing from 363.433 billion yuan in 2014 to 507.58 billion yuan in 2023. The output of the secondary industry has significantly increased, rising from 308.545 billion yuan to 5690.966 billion yuan during the same period. The output growth of the tertiary industry has been even greater, from 3059.949 billion yuan in 2014 to 662.367 billion yuan in 2023. In 2015, it surpassed the secondary industry and became the dominant force in the total economic output, in industrial sector.

From 2014 to 2023, Jiangsu's economic system has achieved great development, and the industrial structure has changed from the traditional "two three one" model to the "three two one" layout. The important factor to promote this change is a series of strategic measures implemented by the Jiangsu provincial Government in the

past decade. These measures aim to gradually shift the focus of investment from Resource-intensive industries to innovation driven industries, so as to effectively promote the optimization and upgrading of the industrial structure. As far as the country is concerned, the output value of the tertiary industry accounts for 53.9%, and that of Jiangsu province is 51.66%, which is significantly lower than the national average. The current economic structure of Jiangsu province shows the characteristics of the “three two one” pattern. However, from the quantitative indicators, the output of the tertiary industry has no significant advantage over the secondary industry. This shows that there is still huge growth potential and improvement space for the development of the tertiary industry.



**Figure 1.** Output value of the three major industries in Jiangsu Province from 2014 to 2023.

#### 4.3. Empirical analysis of the impact of green finance on the optimization and upgrading of industrial structure in Jiangsu province

This article uses a panel dataset of thirteen prefecture level cities in Jiangsu Province from 2014 to 2023 as the main analysis material. The data is sourced from statistical yearbooks of various regions in Jiangsu Province, and interpolation is used to process variables with missing values. It is important to understand several core elements in model construction: the target dependent variable, the explanatory variable at play, and the control variable used to correct potential biases. The dependent variable is the optimization of industrial structure, which is obtained by the ratio of the added value of the tertiary industry to the added value of the secondary industry. The explanatory variable is green finance, which requires a series of quantitative indicators including the scale and proportion of green financial instruments such as green credit, green bonds, green insurance, green funds, and green equity. The controlled variables include the level of economic development, degree of government intervention, level of social consumption, and population distribution.

Based on the selection of the above variables, this paper will build the following model:

$$Super = \alpha + \beta Green_{it}$$

$$Super = \alpha + \beta Green_{it} + \gamma Controls_{it} + \varepsilon_{it}$$

Among them, super represents the explained variable, green represents the explanatory variable, and control represents the control variable. The descriptive statistics of each variable are shown in **Table 2**.

**Table 2.** Statistical description of variables

Variable	Sample value	Average value	Minimum value	Maximum value	Standard deviation
Super	130	1.050	0.788	1.734	0.188
Green	130	0.400	0.130	0.714	0.137
GDP	130	11.50	10.44	12.20	0.435
People	130	6.634	6.192	6.998	0.209
GOV	130	0.123	0.084	0.197	0.029
Consume	130	0.350	0.221	0.497	0.068

To further explore the initial relationship between explanatory and dependent variables in the model, this article uses Pearson correlation coefficient as a statistical tool for analysis. The results show that the coefficient value of the green variable is 0.222, which shows a significant positive correlation at the 15% significance threshold, indicating that the green variable has a positive impact on the dependent variable. Therefore, a preliminary conclusion is drawn: the development of green finance in Jiangsu Province plays a crucial role in promoting the improvement and upgrading of its industrial structure towards higher efficiency and environmental protection. The correlation test is shown in **Table 3**.

**Table 3.** Correlation test

	Super	Green	GDP	People	GOV	Consume
Super	1					
Green	0.222**	1				
GDP	0.377***	0.108	1			
People	0.323***	0.00700	0.503***	1		
GOV	-0.0990	0.0100	-0.821***	-0.587***	1	
Consume	0.644***	0.183**	-0.111	0.0970	0.185**	1

Note: \*, \*\*, \*\*\* respectively indicate that the corresponding indicators are significant at the 10%, 5%, and 1% levels.

Subsequently, this article employs the stepwise regression method for analysis, as shown in **Table 4**. In Equation (1), separate analyses are conducted for the explanatory and dependent variables, with a coefficient value of 0.313 for the green indicator, indicating a significant positive effect at the 1% significance level. Equation (2) further explores this situation by adding control variables to the model to consider the potential impact of other factors. The revised analysis shows that green's coefficient has been reduced to 0.107, but it still maintains a positive trend at a significance level of 5%.

**Table 4.** Empirical results of the impact of green finance on industrial structure

Variable	Formula 1	Formula 1
	Super	Super
	(5.23)	(2.25)
Green	0.313***	0.107**

**Table 4 (Continued)**

Variable	Formula 1	Formula 1
GDP		0.296*** (9.48)
People		0.247 (1.20)
GOV		1.893*** (2.99)
Consume		0.707*** (4.17)
_cons	0.925*** (36.77)	-4.513*** (-3.22)
N	130	130
R-Squared	0.191	0.594
F	27.398	32.755

From **Table 4**, it can be seen that green finance plays an indispensable role in promoting the improvement and upgrading of industrial structure, especially through mechanisms such as funding guidance, innovation promotion, and resource integration, effectively assisting the development of green environmental protection industry. This not only increases the scale of green industry, but also further stimulates the vitality of the tertiary industry, promoting the entire industrial structure to develop towards a more efficient and sustainable direction. Although the correlation coefficient is relatively small, it precisely indicates that the current development of green finance in Jiangsu Province has just entered the stage of moving from the beginning to maturity. Based on this, Jiangsu Province should further strengthen investment in the development of green finance and deepen the degree of transformation. Furthermore, there is a clear positive correlation between the level of economic development and the improvement and enhancement of industrial structure, indicating that economic growth can effectively promote the rational allocation of resources and facilitate their flow towards the more efficient tertiary industry.

The degree of government intervention has outstanding positive significance for the optimization and upgrading of industrial structure. In this situation, the Jiangsu provincial government has continuously introduced and implemented a series of related policies in accordance with the national strategy of promoting green finance. With financial support, technological innovation guidance and other methods, it focuses on addressing environmental pollution problems and uses this as a breakthrough point to promote further improvement and upgrading of industrial structure. According to empirical analysis, the development of green finance has brought significant economic benefits to Jiangsu Province and achieved good results in environmental protection, which well confirms its positive role in optimizing and upgrading industrial structure.

## 5. Conclusion

According to the empirical research results in the previous section, green finance can to some extent promote the development of Jiangsu province's industrial structure towards optimization. However, due to various reasons



such as supply-demand imbalance and limited resource allocation, its actual effect has not yet been fully released. In response to the problems of imperfect policy system, immature market development, and obstacles to industry finance integration in the upgrading of green finance and industrial structure in Jiangsu Province, combined with theoretical analysis and empirical conclusions, systematic policy recommendations are proposed from three dimensions: institutional design, market cultivation, and technological support, in order to promote the deep integration of green finance and industry and accelerate the construction of a low-carbon and efficient modern industrial system.

## 6. Recommendation

Therefore, this article proposes the following suggestions: Firstly, the Jiangsu provincial government should adopt policy measures such as tax incentives and fiscal incentives to encourage financial institutions to vigorously carry out green finance business and achieve good results. For commercial banks with a high proportion of green credit, their business tax collection rate can be moderately reduced; Provide specialized subsidies to financial institutions that have successfully issued green bonds to offset their issuance costs, thereby greatly stimulating their enthusiasm and initiative to engage in green finance business. Secondly, the government has established a negative list system for green finance businesses and tightened control over financing support for high pollution and high energy consumption categories. Require financial institutions to establish a full process environmental risk assessment mechanism, dynamically track green projects, and implement environmental risk stress testing for high carbon projects. Finally, in order for financial institutions to innovate, they must develop diverse green financial tools, establish a green supply chain financial service system, create financing channels for enterprises related to the environmental protection industry chain, launch green themed credit card products for individual users, promote low-carbon consumption concepts through point rewards and rate discounts, improve the green insurance product system, and provide comprehensive risk prevention guarantees for ecological protection projects.

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# Comparative Analysis of Mineral Rights Licensing Systems in Tanzania and Uganda

Mudan Huang\*

Shenzhen Polytechnic University, Shenzhen, China

*\*Author to whom correspondence should be addressed.*

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**Abstract:** In order to promote the development of the mineral industry in their countries, Tanzania and Uganda have revised their mining acts in recent years, and the reform of the mineral rights licensing system is one of the key points. This paper is intended to make a comparative analysis of the two countries' mineral rights licensing systems in terms of the main body of approval, approval time, approval information, approval conditions and application fees. Through comparison, it can be seen that the two countries focus on the role of the government in the mineral rights licensing, jurisdiction is more centralized, access system is fairer, the review is more stringent, and the provisions are clearer and more concise. On the whole, Tanzania's mineral rights licensing system is more detailed and standardized than Uganda's, and is more operational in practice. In addition to exploring the advantages of the two countries' mineral rights licensing system, this paper also summarizes and analyzes the shortcomings of the two countries' mineral rights licensing system, how to verify the review of information in the two countries' mineral rights licensing system, how to effectively supervise the activities after licensing, and how to continue to deepen the reform of the two countries' ministries of mines and minerals, which are responsible for the important task of strengthening the administrative capacity and improving the efficiency of the administration, is still an important issue that deserves continuous and in-depth study for the two countries. For both countries, this is still a topic that deserves continuous and in-depth research. Through the comparative analysis of the Tanzanian and Ugandan mineral rights licensing systems, this paper clearly demonstrates the similarities and differences between the two systems as well as their advantages and disadvantages, which can provide decision-making references for relevant mining investments and help investors more comprehensively assess the legal environment, policy risks and operating costs of mining development in the two countries, so as to optimize their investment strategies and reduce compliance risks.

**Keywords:** Mineral rights; Licensing systems; Tanzania; Uganda

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## 1. Introduction

In order to develop new economic growth points for the national economy and tap the potential of their economic

sectors, Tanzania and Uganda in East Africa have in recent years taken the mineral industry as a key area of development, and have successively amended their mining acts and introduced a series of supporting policies. However, although the two countries have carried out reforms in the licensing system of mineral rights, there are still many problems in the actual implementation: “how to improve the efficiency of approval? How can information review and follow-up supervision be effectively linked”? “How can the government’s management capacity adapt to the needs of mining development”?

The purpose of this paper is to systematically analyze the similarities and differences between the Tanzanian and Ugandan mineral rights licensing systems through comparative analysis, in terms of the dimensions of the main body of the approval process, approval time, approval materials, approval conditions, and application fees, etc., and to focus on the following issues: firstly, the strengths and weaknesses of the systems of the two countries in terms of fairness and operationalization; secondly, the deficiencies of the existing regulations in practice, such as the transparency of the approval process, the lack of a supervisory mechanism, and so on; and thirdly, how to optimize the system design to reduce investors’ compliance risk. Through this study, this paper hopes to provide investors with decision-making references, and at the same time make suggestions for further improving the mineral rights licensing system in both countries.

## **2. Comparison of system content**

### **2.1. Category of mineral rights**

In terms of the type of provision for mineral rights, the types of provision in Tanzania and Uganda are not identical, and even the terminology is different. The Tanzania Mining Act 2010 has stipulated prospecting license, retention license, special mining license, mining license, primary license, processing, smelting and refining license. The Uganda Mining Act 2003 has stipulated prospecting license, exploration license, retention license, mining lease, location license, mineral dealer’s license was seen that Tanzania provides for a wider and more detailed range of mineral rights than Uganda.

### **2.2. Approval authority**

The Tanzania Mining Act 2010 stipulates that applications for exploration licenses are to be made to the Commissioner of Mines appointed by the President; applications for retention licenses, special mining licenses, and mining licenses are to be made to the Minister of Mines; and applications for junior mining licenses are to be made to the Regional Mining Officer. The Uganda Mining Act 2003 stipulates that applications for exploration licenses, exploration licenses, mining leases and local licenses are to be approved by the Commissioner of Mines. It can be seen that the approval authority of the Commissioner of Mines in Uganda is more centralized, while that of Tanzania is differentiated according to the type of mineral rights and is more concerned with administrative efficiency.

### **2.3. Information to be provided in the application**

#### **2.3.1. Prospecting license**

The Uganda Mining Act 2003 stipulates that an application for a prospecting license must be made to the Commissioner in the prescribed form and on payment of the prescribed fee, and that the application may contain any matter which the applicant proposes to have considered by the Commissioner. The Tanzanian Mining Act 2010 does not stipulate for this type of license.



### 2.3.2. Exploration license

The Tanzanian Mining Act 2010 stipulates that an application for the grant of an exploration license shall contain, in the case of an individual, his full name and nationality, physical and postal addresses, and attach his recent passport size photograph; or in the case of a body corporate, its corporate name, place of incorporation, names and nationality of directors; in the case of more than one person, particulars referred in items (i) and (ii) of each of that person. The application shall state the type of minerals and its relevant group, as indicated in subsection (1); shall state the size of the area of land over which it is sought, which shall not exceed the maximum area prescribed as provided under section 70, and be accompanied by a plan of the area; shall contain a statement giving particulars of the financial and technical resources available to the applicant; and shall contain a statement on the procurement plan of goods and services available in the United Republic; shall contain details of any Mineral Right previously granted to the applicant <sup>[1]</sup>. The Uganda Mining Act 2003 stipulates that an application for an exploration license shall be made to the Commissioner in the prescribed form and upon payment of the prescribed fee; be accompanied by a plan of the area over which the license is sought, drawn in such a manner and showing such particulars as may be prescribed; identify the minerals in respect of which the license is sought; give in respect of the person or, if there is more than one person, the name and nationality of each person, making the application; in the case of a body corporate, its name and place of incorporation, the names and nationalities of the directors, managers and other officers of a similar rank, and if the body corporate has a share capital, the name of any person who is the beneficial owner of more than five per cent of the issued share capital; information on the financial status and the technical and industrial competence and experience of the applicant <sup>[2]</sup>.

From the above, it can be seen that Tanzania and Uganda have basically the same requirements for the information to be provided when applying for exploration licenses. The difference lies in that Tanzania requires more specific information, while Uganda places more emphasis on the commercial feasibility and transparency of the minerals being explored.

### 2.3.3. Retention license

The Tanzanian Mining Act 2010 stipulates the holder of a prospecting license other than a prospecting license for building materials or gemstones may apply to the Minister for the grant of a retention license on the grounds that he has identified a mineral deposit within the prospecting area which is potentially of commercial significance; and the mineral deposit cannot be developed immediately by reason of technical constraints, adverse market conditions or other economic factors which are, or may be, of a temporary character. An application for a retention license shall be accompanied by studies and assessments by appropriate independent experts or consultants acceptable to the Minister on the extent, prospects for recovery, and the commercial significance of the mineral deposit, and the relevant market conditions, trends, technical and economic factors; the impact of mining operations for the recovery of the mineral deposit on the environment and the manner of eliminating or minimizing any adverse effects; and such other information as the Minister may reasonably require as to the proposals of the applicant for the retention and development of the deposit <sup>[3]</sup>. The Uganda Mining Act 2003 stipulates an application for a retention license shall be accompanied by the prescribed fee and the following a full feasibility study and assessment by appropriate experts or consultants acceptable to the Commissioner on the extent and prospect for recovery and the commercial and economic significance of the mineral deposit concerned; the impact of mining operations on the environment and ways and means of eliminating or minimizing any adverse effects; and such other information as the Commissioner may reasonably require regarding the proposals of the applicant for the

retention and development of the deposit <sup>[4]</sup>.

As can be seen from the above, both countries allow for postponement of development due to market or economic factors, but Tanzania has a longer reservation period (10 years), which is suitable for long-term strategic reserves; Uganda, on the other hand, pays more attention to short-term adjustments (3 years).

#### **2.3.4. Mining license**

The Tanzanian Mining Act 2010 stipulates every application for mining license shall identify the relevant prospecting license; describe the area, not exceeding the maximum area prescribed over which a mining license is sought, and shall be accompanied by a sketch plan in sufficient detail to enable the Minister to identify the area; describe the mineral deposits in the proposed area; include a feasibility study which should set out- the proposed program of mining operations including such measures as the applicant proposes to take in relation to any adverse impacts to the environment; the estimated recovery rate of ore and the applicant's proposals for its treatment and disposal; the applicant's estimate of the quantity of minerals to be produced for sale annually; and shall state the duration, not exceeding ten years, for which the mining license is sought; append a plan on employment and training of Tanzanians and succession plan on expatriate employees in accordance with the Employment and Labor Relations Act as appended to the special mining license; include a statement giving particulars of financial and technical resources available to the applicant; submit a procurement plan of goods and services available in the United Republic <sup>[5]</sup>. The Uganda Mining Act 2003 stipulates that an application for the grant of a mining lease shall be made to the Commissioner; indicate financial and technical resources available to the applicant to carry out his or her obligations under such lease; be accompanied by a full feasibility study including a plan of the area in respect of which the lease is sought; state the period for which the lease is sought; give or be accompanied by a statement giving details of the mineral deposits in the area of land over which the lease is sought, including details of all known minerals proved, as well as possible and probable ore reserves and mining conditions; be accompanied by a technological report on mining and processing techniques proposed to be used by the applicant; give or be accompanied by a statement giving particulars of the programmed of proposed development and mining operations, including a statement of the estimated capacity of production and scale of operations; the estimated overall recovery of the ore and mineral products; and the nature of the mineral products; be accompanied by a report on the goods and services required for the mining operations, which can be obtained within Uganda and the applicant's proposals with respect to the procurement of those goods and services; be accompanied by a statement giving particulars of the applicant's proposals with respect to the employment and training of citizens of Uganda; be accompanied by a business plan giving a detailed forecast of capital investment, operating costs and revenues; and the anticipated type and source of financing including the year for the positive cash flow and financial plan and capital structure <sup>[6]</sup>.

From the above, it can be seen that both countries have common requirements regarding core information such as details of the mineral deposits for which mining licenses are applied, mining operation plans, feasibility studies, local employment and training, and local procurement plans. There are two differences: firstly, the approval authority for mining licenses in Tanzania is the Minister of Mines, while in Uganda, it is the Commissioner of Mines; secondly, Tanzania places more emphasis on environmental and social responsibility, highlighting its emphasis on environmental protection and community rights and interests, while Uganda has relatively relaxed requirements in these areas.

## **2.4. Examination and approval conditions**

### **2.4.1. Prospecting license**

The Uganda Mining Act 2003 stipulates that no prospecting license shall authorize the holder of the license to prospect over an area of land that is, or forms part of an exploration area, a mining area, a retention area or a location license area; or a forest reserve, game reserve, national park, or an urban center, unless the holder of the prospecting license has first given notice to and obtained permission from the relevant authorities and complies with any conditions imposed by such authorities <sup>[7]</sup>.

### **2.4.2. Exploration license**

The Tanzanian Mining Act 2010 stipulates that an applicant for a exploration license whose application was properly made under section 28 and an applicant whose application has been declared to be a successful application under section 29 shall be entitled to the grant of a prospecting license for which he has applied unless he is disqualified from holding a prospecting license under section 8; he is the holder of another mineral right and is, in respect of that other mineral right, in default; the financial and technical resources available to the applicant are not adequate; the area of land for which he has made application or part thereof is subject to another mineral right; the area of land for which application has been made, or any part of it, covers or includes an area designated by the Minister under section 16 as an area reserved for prospecting and mining operations by persons holding primary mining licenses; the area of land for which application has been made covers or includes an area of land for which application has been made by another person who has priority over the applicant under section 14; except in a case to which section 29 applies, the area of land for which application has been made, or any part of it, covers or includes an area deemed to have been designated or designated by the Minister under section 15 as an area in respect of which applications for the grant of a mineral right shall be invited by tender <sup>[8]</sup>. The Uganda Mining Act 2003 stipulates that no exploration license shall be granted to an applicant unless the Commissioner is satisfied that the applicant has adequate financial resources, technical competence and experience to carry on effective exploration operations; the program of proposed exploration operations is adequate for the period of the license; the applicant's proposal for exploration operations has provided for the employment and training of Ugandan citizens; the applicant is able and willing to comply with the terms and conditions of the exploration license; the minerals to which the proposed exploration license relate exist in the proposed exploration area; and the applicant is not in default <sup>[9]</sup>.

From the perspective of approval conditions, Tanzania adopts a hybrid approval model (direct application + bidding), where some regions require bidding competition, with a focus on evaluating the contribution of bidding proposals to the “rapid and beneficial development” of mineral resources (such as expenditure commitments, operational plans, and historical experience). It also explicitly excludes conflicts between reserved areas for primary mining and priority application areas. Uganda's approval process relies more on the subjective judgment of commissioners, requiring compliance with flexible conditions such as “effective exploration operations” and “willingness to comply with terms”. Furthermore, Uganda demonstrates localization requirements here, explicitly requiring that exploration plans include employment and training for Ugandan citizens, reflecting a social benefit orientation.

### **2.4.3. Retention license**

The Tanzanian Mining Act 2010 stipulates where the commercial development of the deposit is not presently

possible for the reasons specified in the application, but may be possible within a period of ten years, the Minister may grant a retention license to the applicant over that part of the prospecting area which the Minister, after consultation with the applicant, anticipates is required to mine the deposit identified by the applicant <sup>[10]</sup>. The Uganda Mining Act 2003 stipulates that the Commissioner is satisfied that commercial development of a mineral deposit is not presently possible for reasons specified in an application for a retention license, but may be possible within a period of three years from the date of the application, the Commissioner may grant a retention license to the applicant over that part of the exploration area <sup>[11]</sup>.

#### **2.4.4. Mining license**

The Tanzanian Mining Act 2010 stipulates the circumstances under which mining licenses will not be approved, including the applicant is a person to whom section 8 applies; the area in respect of which a mining license is sought is in excess of the area required to mine the deposits identified by the applicant; employment and training program for citizens of Tanzania and succession plan on expatriate employees in accordance with his proposals is not satisfactory; the applicant is or was in default in respect of any other mineral right and has failed to rectify such fault; the applicant is not an entitled applicant and the area of land for which the applicant has made application or part of it is subject to another mineral right, other than a prospecting license for building materials or gemstones; the area of land for which application has been made, or part of it, covers or includes an area designated by the Minister under section 14 as an area reserved for prospecting and mining operations by persons holding primary licenses to mine minerals; the area of land for which application has been made covers or includes an area of land for which application has been made by another person who has priority over the applicant under section 14; except in a case of an application made in accordance with section 71, the area of land for which application has been made, or part of it, covers or includes an area designated by the Minister under section 15 as an area in respect of which applications for the grant of a mineral right have been, or will be, invited by tender; financial and technical resources available to the applicant are not adequate for the conduct of mining operations; the applicant has not included an application for mining license the relevant environmental certificate issued under the Environment Management Act <sup>[12]</sup>. The Uganda Mining Act 2003 stipulates the conditions for obtaining a mining lease, including the area of land over which the lease is sought is not in excess of the area reasonably required to carry out the applicant's program of proposed mining operations; the program of proposed mining operations takes proper account of environmental impact assessment, environmental impact research, environmental statement and safety factors; the feasibility study of the relevant ore body indicates that the mineral deposit in question can be profitably mined; the applicant has adequate financial resources, technical competence and experience to carry on effective mining operations; the applicant's proposals for the employment and training of citizens of Uganda are adequate; the applicant's proposals with respect to the procurement of goods and services obtainable within Uganda are satisfactory; the applicant demonstrates a willingness and an ability to comply with the terms and conditions applicable to the mining lease; the applicant has secured the surface rights of the land the subject of his or her application; and the applicant is not in default <sup>[13]</sup>.

In the approval of mining licenses, there are five differences between the two countries. Firstly, in terms of the strictness of approval, Tanzania has clear and specific conditions with multiple quantitative standards, while Uganda has more qualitative requirements with greater flexibility. Secondly, in terms of the degree of localization, Tanzania reflects it through employment and procurement requirements, while Uganda has equity restrictions in addition to employment and procurement. Thirdly, in terms of environmental requirements, Tanzania must provide



environmental certificates, while Uganda requires environmental impact assessments and studies; Fourthly, in terms of regional management, Tanzania has clearly designated reserved areas and bidding areas, while Uganda mainly manages through area control. Fifthly, in terms of approval transparency, Tanzania provides clear and specific reasons for rejection, while Uganda gives opportunities for correction but with vague standards.

## **2.6. Application fees**

The Mining Regulations issued by Tanzania in 2012 stipulate the application fees for various licenses as follows: USD 300 for exploration licenses of metallic minerals, energy minerals, and Kimberlite diamonds; USD 200 for exploration licenses of building materials and gemstones (excluding Kimberlite diamonds); USD 200 for exploration licenses of industrial minerals; USD 4,000 for reserved licenses; USD 5,000 for special mining licenses; USD 2,000 for mining licenses; USD 2,000 for building material mining licenses; and TZS 50,000 for primary mining licenses.

The License Fee Regulations issued by the Ministry of Mines and Petroleum of Uganda on July 1, 2016 stipulates that the annual fee for exploration licenses is 500,000 Ugandan shillings. The application and preparation fees for exploration license, mining lease, retention license, and local license are 1,000,000, 5,000,000, 5,000,000, and 800,000 Ugandan shillings, respectively.

## **2.7. Examination and approval time**

The Tanzania Mining Act of 2010 stipulates that the approval time for an exploration license is within four weeks from the date of registration of the exploration license application, and the applicant shall be notified of whether the application has been approved or rejected; within four weeks from the date of receiving the notification, the applicant shall notify the accepting authority of their willingness to accept the approved license and pay the relevant fees. Failure to send a notification shall be deemed as withdrawal of the application; and the accepting authority shall approve the application and arrange for the issuance of the license to the applicant within four weeks from the date of receiving the notification of acceptance. However, the approval time for special mining licenses, mining licenses, and primary mining licenses is not stipulated in either the Mining Act or the Mining Regulations.

The 2003 Mining Act of Uganda stipulates that the approval time for mining leases is within 60 days after receiving the application for mining leases. However, regarding the approval time for exploration permits, exploration licenses, reservation licenses, and local licenses, there are no relevant provisions in the 2003 Mining Act, 2004 Mining Regulations, or 2000 Mineral Policy of Uganda <sup>[14]</sup>.

# **3. Analysis of the mineral rights licensing system**

## **3.1. Focusing on the changing role of government**

Previously, many African governments preferred to take a small stake in mining enterprises, either in the form of dry shares or in the form of optional participation in the operation or management of mining enterprises, while the mining acts of Tanzania and Uganda both chose to establish a series of tax systems such as surface royalties, annual rents and royalties to safeguard the government's rights and interests in the use of the national resources expenditure, thus realizing the role of the government from a mandatory participant to service-oriented manager <sup>[15]</sup>.

### **3.2. More centralized jurisdiction**

In order to do a good job of changing the role of resource managers, Tanzania and Uganda have respectively set up the Ministry of Energy and Minerals and the Ministry of Mines and Petroleum, which are specifically responsible for minerals and mining matters. As can be seen from the aforementioned review subjects, the departments of these two countries' mineral rights granting departments are mostly concentrated in one department, and the applications, renewals and transfers of mineral rights are all accomplished in the same department, which avoids overlapping or staggered jurisdiction and brings more trouble to the applicants. This avoids the overlapping of jurisdiction or staggering of jurisdiction, which may cause more trouble to the applicant.

### **3.3. Fairer access system**

As mentioned earlier, the division of mineral acts in Tanzania and Uganda is similar, and the mining acts of the two countries do not restrict the applicant's citizenship or the nature of the legal person, that is, foreign companies, national companies, state-owned companies, private companies, foreign investors and domestic investors are treated equally and equally, and different investors are given the same opportunities and treatments in terms of the industry's access; and in terms of the small-scale exploration and mining licenses, the two countries coincidentally choose to favor national citizens or local companies, requiring the applicant to be a national citizen or an enterprise in which national citizens hold 50% of the shares, otherwise they are not qualified to apply. In terms of small-scale exploration and mining licenses, the two countries coincidentally chose to favor their own citizens or local companies, requiring that the applicant must be a national citizen or an enterprise in which a national citizen accounts for more than 50 percent of the shares, or else it will not be eligible to apply. This system is designed to reflect the fairness and impartiality of the acquisition of mineral acts regardless of identity, regardless of national boundaries, can well attract foreign investment to join the country's mineral industry, with the help of foreign capital to open up the power of accelerating the development of the country's mineral industry; Secondly, in line with the national conditions of the country, the African countries themselves have a large number of small-scale mining, artisanal mining, accommodate a lot of the country's labor force, and small-scale mining, artisanal mining and almost all mechanized, labor-intensive, less than a high degree of mechanization <sup>[16]</sup>. Small-scale mining, artisanal mining and almost all are not high degree of mechanization, labor-intensive production, large enterprises do not favor this, small-scale mining, artisanal mining applications to make the subject of the eligibility requirements not only to ensure the survival of small-scale mining enterprises in the local opportunity to survive, but also does not restrict the development of large foreign-funded enterprises, to do so in accordance with the local conditions.

### **3.4. More rigorous review approach**

Unlike the pure bidding access system of the United States, the United Kingdom, Australia, Norway and other countries, and also unlike the first-to-file doctrine of Japan, the Tanzanian and Ugandan mineral acts access system adopts a substantive examination method, which not only requires the applicant's suitability for a small-scale license, but also evaluates the applicant's capacity in terms of its technical ability, financial status, past experience and environmental protection measures in order to select the most capable and competitive enterprise to enter the mineral industry. In the case of large licenses, the applicants are also evaluated on their technical capabilities, financial status, past experience, environmental protection measures and other aspects, with a view to selecting the most capable and competitive enterprises to enter the mineral industry.

### **3.5. Provisions are relatively clear and unambiguous**

As can be seen from the provisions of the Tanzanian and Ugandan mining acts on the subject matter of the approval, the information to be submitted and the conditions for approval, both countries have relatively detailed provisions on the licensing system for mineral rights. In addition, in order to make the provisions of the mining acts better implemented, the corresponding ministries of mines or mines of Tanzania and Uganda have issued corresponding regulations to guide the application of mineral acts, which not only include model forms to be submitted for application, but also have guidelines for all kinds of situations after the submission of the application (e.g., the application will be returned if the information is not complete, etc.), which is of great significance in guiding the applicants of mineral acts without the need to repeatedly consult or wait without any information. This is a great guidance for the applicants of mineral rights, without the need to consult or wait without any clue.

## **4. Deficiencies in the mineral rights licensing systems of the two countries**

### **4.1. The approval time is not transparent**

Tanzania has not stipulated the approval time for some licenses (such as mining licenses), while Uganda only clarifies the approval time limit for mining leases. The lack of time constraints for other licenses may affect investment efficiency.

### **4.2. Weak supervision mechanism**

Both countries lack detailed regulations for the supervision of mining activities after licensing, especially in terms of environmental protection and community rights and interests' protection, and the enforcement may be insufficient.

### **4.3. Contradictions in localization requirements**

Uganda's equity restrictions (such as requiring 51% local shareholding for local licenses) may inhibit foreign investment, while Tanzania's employment and procurement requirements, although strict, lack supporting measures.

### **4.4. The reasonableness of cost differences**

Tanzania's cost structure is more segmented (such as by mineral type), but some costs are relatively high (such as \$5,000 for a special mining license); Uganda's costs are relatively uniform, but local enterprises may be at a disadvantage due to the annual fee burden.

## **5. Mining investment suggestions for investors**

### **5.1. Selection of investment destinations**

Investors who prefer regulatory compliance and stability may choose Tanzania, which boasts detailed systems and high transparency, making it particularly suitable for large-scale mining projects. However, they need to anticipate higher compliance costs (such as environmental assessments and local procurement). Investors who prefer flexibility and fast access may consider Uganda, where the approval process is relatively simple, but they need to navigate localization requirements and vague regulatory standards.

## **5.2. Selection of investment destinations**

Conduct advance research on reserved areas and bidding areas: In Tanzania, it is necessary to avoid primary mining reserved areas and designated bidding areas; in Uganda, it is necessary to confirm that the application area has not been designated as a protected area or priority land. Emphasize local cooperation: When investing in Uganda, priority should be given to joint ventures with local enterprises to meet equity requirements; in Tanzania, detailed local employment and procurement plans need to be formulated. Allow sufficient approval time: Especially for license types in Uganda that do not have a clear time limit, a buffer period should be added to the project planning.

## **5.3. Long-term operational advice**

In terms of environmental and social responsibility, both countries are increasingly emphasizing environmental protection and community rights. Investors should conduct environmental impact assessments in advance and establish community communication mechanisms to reduce the risk of conflict. Regarding policy dynamics, the mining acts in both countries are still in the reform stage. Investors need to closely monitor policy changes (such as fee adjustments and revisions to localization provisions) and promptly adjust compliance strategies.

## **5.4. Cost optimization**

Firstly, compare the cost structures. Tanzania's special mining license fees are relatively high, suitable for high-value mineral projects; Uganda's annual fee model is suitable for the medium and long-term exploration stage. Secondly, utilize the retention system. In Tanzania, licenses can be retained (for 10 years) to cope with market fluctuations; Uganda's retention period is shorter (3 years), suitable for short-term adjustments.

## **6. Conclusion**

The mineral rights licensing systems in Tanzania and Uganda both aim to balance resource development and public interests. However, Tanzania places more emphasis on regulation and foreign investment guidance, while Uganda focuses on localization and flexibility. Investors should fully assess the differences between the two systems and their own risk tolerance, choose the optimal investment path based on project characteristics, and actively participate in policy dialogue to reduce compliance risks and enhance long-term returns.

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# Technology in the Cultivation of Composite Talents in the Context of the Free Trade Port

Yun Li\*, Ting Liu, Lili He

Hainan Vocational University of Science and Technology, Haikou 570100, Hainan, China

*\*Author to whom correspondence should be addressed.*

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**Abstract:** As an important strategic fulcrum for China's new round of opening-up, the Hainan Free Trade Port provides broad space for achieving high-quality development with its unique policy advantages and financial resources. In this context, integrating blockchain technology into the construction of the free trade port can not only help enhance the innovation and competitiveness of the talent cultivation system but also promote the coordinated development of the real economy and the industrial system. Based on the core characteristics of blockchain technology, such as "decentralization, traceability, and high credibility", this paper focuses on the common problems in the cultivation of composite talents in current vocational colleges, including an imperfect school-enterprise cooperation guarantee mechanism, a lack of teaching resources, weak teaching staff, and insufficient practical conditions. It proposes a new idea of introducing blockchain technology into the vocational education system. Through the research on the cultivation model of composite-skilled talents in vocational colleges in the context of "blockchain +", this paper aims to promote the in-depth integration of vocational education in vertical and horizontal aspects, and further promote the systematic, standardized, and high-quality development of composite talent cultivation.

**Keywords:** Free trade port; Blockchain; Composite talents

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## 1. Introduction

With the in-depth implementation of the China (Hainan) Free Trade Port strategy, vocational education in Hainan Province is facing development challenges and opportunities at a higher level and in a broader field. In the process of constructing a modern vocational education system, how to meet the actual needs of the free trade port construction for high-quality technical and skilled talents has become an important topic in current education reform<sup>[1]</sup>. Based on the actual development of vocational colleges, this paper explores the in-depth application value of blockchain technology in the cultivation of composite talents, aiming to provide new ideas for education and teaching reform, promote the in-depth integration of industry and education, optimize the professional

structure and talent cultivation system, enhance the practicality and adaptability of education, strengthen the fit between vocational education and regional industrial development, to better meet the diversified needs of enterprises for high-quality technical and skilled talents, build a high-level vocational education brand with Hainan regional characteristics, and provide theoretical support and practical reference for the high-quality development of vocational education.

At the same time, the rapid development of information technology, especially the new-generation digital technologies represented by cloud computing, big data, artificial intelligence, and blockchain, is profoundly reconstructing the social and economic structure and industrial ecology. As an important technical pillar in the digital economy era, since blockchain was listed as a cutting-edge technology for priority development by the State Council in 2016, it has continuously received policy support and market attention. In recent years, the number of blockchain-related enterprises has grown rapidly, the industrial scale has been expanding, and the demand for professional and technical talents has also shown a rapid upward trend. In this context, vocational colleges urgently need to seize the opportunity of digital transformation, face the forefront of industrial development, actively adjust and optimize the talent cultivation model, strengthen technical and skill training, and focus on cultivating high-quality technical and skilled talents who meet the development needs of blockchain and related digital industries. This is not only of great significance for supporting the sustainable and healthy development of the blockchain industry but also provides a new breakthrough for the connotative and innovative high-quality development of vocational education<sup>[2]</sup>.

## **2. Overview of blockchain technology**

Blockchain technology is an innovative information infrastructure that integrates a number of cutting-edge computer technologies, such as distributed data storage, peer-to-peer transmission, consensus mechanisms, and encryption algorithms. It is particularly suitable for data management and value transfer scenarios in the Internet era. Its core features include a distributed architecture, decentralization, anti-tampering, high transparency, and traceability<sup>[3]</sup>. These features significantly enhance the security of system operation and the credibility of data, showing unique advantages in reducing transaction costs, improving operation efficiency, optimizing the social credit system, and demonstrating broad application potential.

At present, blockchain technology has been applied in many specific scenarios in the financial field, such as transaction clearing, trade finance, supply chain financing, insurance, leasing, and securities management. It has gradually expanded to the real-economy fields such as audit supervision, precision marketing, electronic evidence storage, intelligent manufacturing, supply chain management, product traceability, intellectual property protection, medical and health care, public welfare and charity, and e-government<sup>[4]</sup>. The wide penetration of blockchain not only accelerates the digital transformation of traditional industries but also provides solid technical support and innovative impetus for promoting the development of the digital economy and building a trustworthy social infrastructure.

## **3. Practical explorations of blockchain talent cultivation in domestic universities**

With the rapid development of blockchain technology and its wide application in multiple fields, global higher education institutions have successively set up relevant courses and research directions, striving to gain an edge in talent cultivation. According to the “2018 China Blockchain Talent Status White Paper” released by LinkTower

Think Tank and Lagou.com, 29 universities around the world have offered blockchain courses, including Stanford University, the Massachusetts Institute of Technology, the University of Cambridge, and the University of Oxford. The number of Chinese universities reached 10, ranking first in the world<sup>[5]</sup>.

Well-known domestic universities such as Tsinghua University, Fudan University, and Shanghai University of Finance and Economics have systematically offered blockchain-related courses for undergraduates and postgraduates<sup>[6]</sup>. For example, Central University of Finance and Economics has built the first school-enterprise joint laboratory based on blockchain in China; Tongji University participated in the research of the digital currency of the People's Bank of China and established the "Blockchain Intelligence Laboratory"; in 2023, Tsinghua University initiated the establishment of the National Blockchain Education Alliance for Universities, the "Ivy Chain Alliance", to promote resource sharing and collaborative development.

In contrast, vocational colleges started relatively late in blockchain talent cultivation, and related explorations are still limited. For example, Guangdong Lingnan Institute of Technology, in line with the local blockchain industry's needs, has opened courses in the blockchain application direction. The first batch of students were pre-booked by many enterprises before graduation, reflecting the urgent market demand for technical and skilled talents.

From the perspective of educational technology innovation, the application of blockchain in higher education mainly focuses on three aspects: academic degree certification, teaching reform, and educational model reconstruction. In terms of academic degree certification, universities such as Holberton School and MIT have used blockchain to ensure the authenticity and security of academic degree information<sup>[7]</sup>. In terms of teaching reform, 27 universities around the world, including Tsinghua University, Zhejiang University, MIT, and the University of Oxford, have opened blockchain courses to promote the cultivation of technical talents. In terms of the educational model, scholars from the University of Oxford founded Woolf University, an online university based on blockchain, which supports students in independent course selection, online payment, and credit certification, realizing the decentralization of education.

In China, the application of blockchain in higher education is still in the theoretical exploration stage. Scholars such as Chen believe that the introduction of blockchain technology will break down the information barriers between educational institutions, promote multi-party cooperation among schools, enterprises, and between schools, and jointly build an educational innovation ecosystem across schools, regions, and industries. Li *et al.* believe that blockchain provides a decentralized learning method, which can authenticate various learning achievements and provide technical support for the construction of a credit bank. Li tried to integrate the blockchain incentive mechanism into online education platforms to enhance learners' continuous learning motivation. Li *et al.* proposed that the introduction of blockchain technology will break the inherent centralized space-time organizational structure in vocational education, which is helpful to improve the allocation efficiency of educational resources and promote the in-depth transformation of the educational model<sup>[8]</sup>.

Although the above-mentioned research has widely explored the application of blockchain in the education field, most of it remains at the theoretical level, especially in the practical application of cultivating composite talents in vocational colleges. Therefore, this paper will be based on the core characteristics of blockchain technology-decentralization, data authenticity, self-trust mechanism, consensus maintenance, openness, and a certain degree of anonymity, and explore its specific application paths in the cultivation model of composite talents in vocational colleges. By using blockchain technology to build a vertically connected and horizontally interoperable vocational education system, it can effectively solve the problems existing in current vocational

education in resource allocation, process supervision, talent evaluation, etc., and promote the development of vocational education towards a more systematic and information-based direction<sup>[9]</sup>.

## **4. Research on the cultivation model of composite-skilled talents in vocational colleges in the context of “Blockchain +”**

### **4.1. Exploring the integrated practical teaching model of “courses + projects”**

To improve students’ practical operation ability and project combat experience, some universities have explored and constructed a trinity practical integrated teaching model of “course teaching + project training + competition-driven”. By introducing real-world blockchain projects into the classroom, students are guided to participate in tasks such as smart contract development, on-chain data evidence storage system design, and blockchain prototype application construction, realizing the transformation of “learning by doing and doing by learning”. Some universities and enterprises jointly build blockchain training bases, establish technical laboratories, and organize students to participate in competitions such as the National Blockchain Technology Innovation Competition for Universities, the “Internet +” College Student Innovation and Entrepreneurship Competition, and the China Software Cup, to promote learning and training through competitions and strengthen students’ comprehensive practical ability and technical innovation awareness<sup>[10]</sup>.

### **4.2. Deepening school-enterprise joint construction and promoting the collaborative education of “industry, teaching, research, and innovation”**

With the in-depth promotion of the integration of industry and education policy, the cooperation between universities and leading blockchain enterprises in talent cultivation, curriculum construction, and scientific research has been continuously deepened<sup>[11]</sup>. For example, some universities cooperate with enterprises such as Alibaba, Tencent, Ant Chain, and Baidu Super Chain to develop joint courses, build training platforms, implement the “dual-tutor” system, and jointly declare scientific research projects, creating a collaborative development mechanism for industry, teaching, research, and innovation. This mechanism not only realizes the real-time connection between curriculum content and industrial technology but also provides students with a learning scenario close to reality, enhancing the vocational adaptability and job competence of talent cultivation.

### **4.3. Promoting interdisciplinary integration and expanding the cultivation path of composite talents**

Blockchain technology has significant interdisciplinary characteristics, and its wide application determines that talent cultivation cannot be limited to the fields of computer or information technology<sup>[12]</sup>. Some universities have carried out the construction of interdisciplinary integrated curriculum systems such as “blockchain + finance”, “blockchain + law”, and “blockchain + management”. For example, law-based universities add courses such as “Blockchain Compliance and Digital Asset Law”, and finance-based universities offer professional modules such as “Blockchain and Digital Finance” and “Blockchain-Empowered Supply Chain Finance”. Such interdisciplinary integration cultivation paths help to cultivate composite talents with both technical capabilities and industry knowledge, and enhance the comprehensive competitiveness and innovation ability of graduates in actual positions<sup>[13]</sup>.



#### **4.4. Building a blockchain-based open education platform to promote resource sharing and lifelong learning**

In response to the common problems of uneven resource allocation and insufficient teaching staff in current vocational education, some universities, jointly with scientific research institutions and technology enterprises, have developed blockchain-based online education platforms for the public, such as “MOOCs”, “micro-majors”, and university education resource sharing platforms. These platforms not only serve students on campus but also are open to social learners, supporting the goals of continuing education and lifelong learning and promoting the popularization of blockchain technology and educational equity<sup>[14]</sup>. At the same time, relying on the collection and analysis of learning behavior data on the platform, universities can realize the digitalization and precision of teaching management, providing technical support for personalized teaching and the construction of a smart education ecosystem.

#### **4.5. Constructing an authoritative assessment and evaluation system based on blockchain**

With its anti-tampering and traceability characteristics, blockchain technology makes it possible to establish a more scientific and fair education evaluation system. In the assessment and management links, vocational colleges can build a blockchain-based intelligent management platform, design an assessment system combined with enterprise skill standards, and realize the whole-process data recording from the learning process to the output of results. The system can automatically capture students’ learning duration, participation frequency, practical operation tracks, etc., and teachers can give accurate scores based on this, promoting the construction of a differential and multi-dimensional evaluation mechanism<sup>[15]</sup>. In addition, blockchain can also be used to store and authenticate students’ academic qualifications, skill certificates, and other information, improving the credibility of graduates’ information, enhancing enterprises’ recognition of vocational college talents, and building a trust bridge between schools and enterprises.

### **5. Conclusion**

At present, vocational colleges in China face practical challenges such as large differences in the foundation of students and unbalanced student ability structures, and there is an urgent need to improve the quality of talent cultivation. Based on the actual development of vocational education, this paper explores the internal needs and realization paths of cultivating composite-skilled talents in vocational colleges in the context of “blockchain +”, and proposes to deeply integrate blockchain technology into the whole process of talent cultivation.

By constructing an open-shared, intelligent-managed, and trustworthy evaluation education system based on blockchain, it not only helps to optimize the allocation and wide sharing of educational resources but also promotes the transparency of the teaching process and the scientificization of the evaluation mechanism, thus promoting the transformation and upgrading of vocational education from “knowledge transfer” to “ability cultivation”. At the same time, with the technical advantages of blockchain in identity authentication, learning record tracking, and result traceability, it can effectively enhance enterprises’ trust in the abilities and qualities of graduates and strengthen the collaborative cooperation between schools and enterprises in joint talent cultivation and delivery.

In the future, vocational colleges should continue to actively explore in the integrated development of “technology + education”, build a more open, trustworthy, and intelligent education ecosystem with the help of blockchain technology, promote the high-quality and connotative development of vocational education, and

provide solid talent support for the construction of national strategic emerging industries and the digital economy.

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# Institutional Logics and Its Application in Entrepreneurship Research

Mengxuan Qin\*

University of Stirling, Stirling FK9 4LA, UK

*\*Author to whom correspondence should be addressed.*

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**Abstract:** Institutional logic theory, a pivotal framework within organizational studies, delineates the multifaceted and intricate logics that underpin organizational fields. This theoretical perspective elucidates the manner in which diverse individuals or groups within an organization internalize and manifest distinct institutional logics, alongside the ensuing political and cultural conflicts. Furthermore, the theory endeavors to elucidate the complexities inherent in institutional logic across organizational fields, examining the reflection of these logics among various individuals or groups and their associated political and cultural dichotomies. Central to this discourse is the acknowledgment of the core systems that constitute the fabric of a country, encompassing the state, market, familial structures, corporate entities, professional bodies, and religious institutions. These components not only coexist with inherent conflicts but also exhibit a high degree of interdependence, underlined by their shared institutional logics. This literature attempts to review and analysis institutional logic in the field of entrepreneurship and integrates institutional logic into entrepreneurs' personal background, experience, and other social characteristics, and study how institutional logic operates. It is recommended that future researchers take entrepreneurs as the research object and conduct more in-depth research on the evolution of organizational response strategies when political and cultural conflicts occur between different groups within the enterprise, combined with institutional logic theory.

**Keywords:** Institutional logic; Entrepreneurship; Entrepreneur

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## 1. Introduction

The review uses critical and descriptive research methods to review the theory of institutional logics, discusses the necessity and key issues of applying this theory to entrepreneurship, explains how various institutional logics interact and the coping strategies of entrepreneurs and their businesses. This article employs both critical and descriptive research methodologies to undertake an analysis of institutional logic theory. This theory is primarily concerned with delineating the myriad complex institutional logics that permeate the organizational field. Furthermore, it explores the manner in which diverse individuals or groups within an organization internalize

and exhibit distinct institutional logics, alongside navigating the resultant political and cultural conflicts. In the entrepreneurship field, institutional logic needs more studies as the personal traits for entrepreneurs themselves, such as their residence state, family background, personality, life experiences, may influence the extent of success not only their own life but also the companies they have created. Additionally, the internal running models for the organizational structure and operational principles of those enterprises should also be closely examined regarding the institutional logic.

The review is intended to be a scholastic review with the main purpose of systematically studying institutional logic in entrepreneurship. The reason to make a scholastic rather than interventionist review is due to the academic nature of the literature and the discussion and exploration nature for further research opportunities. The review has no intention to draw conclusions on practical problems. The main methodology employed in the construction of the argument in this review is based on an inductive method, which seeks to build from the observations to the theory rather than deductive hypothesis testing or quantitative methods. The review is conducted as follows: First, the general institutional logic theory is reviewed and summarized; Second, the application of institutional logic in entrepreneurship field is reviewed. The general institutional logic in entrepreneurship is discussed first, such as the complexity and environmental factors, with two main topic covered next, namely institutional logics for entrepreneurship teams and hybrid organizations. The research is intended to be descriptive and critical with study of the current and historical research on institutional logic first, and attempts to find out the gap later.

## 2. Research methodology

This study employs a systematic literature review combined with an analytical approach to explore the concept of institutional logics in entrepreneurship. The methodology is meticulously designed to ensure rigor, comprehensiveness, and relevance, addressing both theoretical and empirical gaps in the existing body of knowledge.

For literature search, to construct a foundational understanding of institutional logics within the entrepreneurship context, a comprehensive literature search was conducted. The databases searched include IEEE, Springer, JSTOR, and specific academic libraries, chosen for their extensive coverage of management and entrepreneurship research. The search terms used were “institutional logic,” “entrepreneurship,” and combinations thereof, with filters applied to include documents published within the last ten years to ensure timeliness. The selection criteria focused on articles that are peer-reviewed, authoritative, and have a significant citation impact. Duplicate studies were excluded, and a final set of over 50 seminal articles was identified for in-depth review from the rough number of over 260,000 articles relating to the topics.

The cited literature within the document spans a range of publication years, reflecting a broad spectrum of research on institutional logics and entrepreneurship. From the 1970s to 1990s, early foundational works such as Meyer and Rowan (1977) and North (1990) are included in this review, indicating that the paper draws on seminal theories and concepts that have shaped the understanding of institutional theory and organizational behavior over decades <sup>[1, 2]</sup>. In the 2000s, several key studies from the early 2000s are reviewed, including Lounsbury and Glynn (2001), and McPherson and Sauder (2013), which marks a significant expansion in the exploration of institutional logics, with researchers delving into the complexities of institutional dynamics and their impact on organizations <sup>[3, 4]</sup>. In the 2010s, a substantial portion of the cited literature comes from the 2010s, such as Pache and Santos (2010), Dunn and Jones (2010), and Greenwood *et al.* (2011) <sup>[5-7]</sup>. This period represents a maturation of research in the



field, with studies addressing the nuanced interplay of multiple institutional logics, the emergence of new logics, and their implications for organizational strategy and entrepreneurship. From the late 2010s to the early 2020s, the inclusion of literatures, such as Paoletta and Durand (2016) and Lee *et al.* (2017), suggests that the paper integrates the most current insights and debates in the field <sup>[8, 9]</sup>. This period is characterized by an increased focus on the practical implications of institutional logics for entrepreneurship, innovation, and corporate social responsibility.

For literature analysis, the selected literature underwent a rigorous thematic analysis to identify recurring themes, concepts, and gaps in the current understanding of institutional logics in entrepreneurship. This process involved summarizing the literature based on predefined and emergent categories, facilitating a structured synthesis of the findings. For empirical insights, where available, the contents of the papers were analyzed using content analysis methods to extract patterns, trends, and relationships that inform the interplay between institutional logics and entrepreneurial activities.

Furthermore, to ensure the rigor and validity of the literature review, multiple strategies were employed. These included cross-referencing findings across different sources, critically evaluating the methodologies of the selected studies, and engaging in discussions with subject matter experts to validate the interpretation of the data. The analytical process was iterative, allowing for continuous refinement of themes and insights based on a comprehensive understanding of the literature.

For a systematic review of institutional logic on entrepreneurship, based on the concepts and origins of institutional logic and the broad application on entrepreneurship, two types of organizations have been on review focus, small startup organizations and hybrid organizations. This is the same as the life span for companies. For startups, the origination team building the organization could be of critical importance. With further expansion, single business startups may experience diversification on their business and productions, which may add complexity and multiple logics on their organizations. Other sorting methods may also be valid, such as divide by industry, but this may ignore the common characteristics for companies during growth. Therefore, growth phase is selected after reviewing the concepts of institutional logic and its broad application in entrepreneurship studies.

### **3. Literature review**

#### **3.1. The development and changes of institutional logics**

Institutional logic is not only a social-level phenomenon, but also manifests itself at different levels such as industries, organizations, and inter-organizations. According to Haveman and Gualtieri (2017), institutional logic is the way that individuals, teams, and organizations evaluate their daily activities and give meaning to these activities <sup>[10]</sup>. Institutional logic is a system of cultural elements that includes cultural elements such as values and expectations, and these elements are closely connected to form a highly consistent and logical system. The two perspectives of institutional logic and new institutionalism have certain similarities. The structural mechanism of the core institutional logic of the modern social institutional system at the social level, and took the lead in proposing the concept of institutional logic. Scholars have emphasized that “country”, “market”, and “family” are interdependent and conflicting entities, as well as “profession” and “company” are also included. Institutional logic provides behavioral norms and organizational principles for individuals and organizations, and provide the basis for perceptions and assumptions, prescriptions, norms, and beliefs. On the basis of previous work, scholars have further explored various mechanisms such as the interaction and alternation of institutional logic at the “organizational field” level. This results in differentiation rather than homogeneity of organizational practices,

which is the result of conflicting core institutions at the social level.

Lee *et al.* believe that different institutional logics that appear at the “field”, “society”, and “community” levels will change due to different historical and cultural situations <sup>[11]</sup>. In addition, Lee *et al.*, (2017) and McPherson *et al.* (2013) believe that organizations and individuals, as actors, will use their own initiative to interpret, deduce, or choose institutional logic out of their own interests and strategic goals <sup>[4, 9]</sup>. Therefore, institutions’ Logical theory is also a cross-level theoretical framework.

The research of Selznick (1948), an early institutional scholar found that an organization is not a completely closed system, and its development will be affected by the surrounding environment <sup>[12]</sup>. On this basis, the new institutional theory points out that the environment facing organizational development includes not only the technical environment, but also the institutional environment. If an organization wants to gain legitimacy from its environment, it must obey the requirements of the institutional environment in the field (Meyer 1977) <sup>[1]</sup>. For example, the study by Scott *et al.* found that as the government and the market replaced doctors as the dominant players in the medical industry, medical companies’ own positioning and corporate strategies have undergone significant changes <sup>[13]</sup>. Dunn and Jones found that due to the involvement of different interest groups, multiple institutional logics coexisted in the American medical education industry, and changes in these institutional logics led to dynamic tensions within the organization <sup>[6]</sup>. Greenwood *et al.*’s research on Spanish companies also showed that differences in local corporate organizational structures and behaviors are caused by the gradual dominance of market logic <sup>[7]</sup>. Both family logic and local government logic will respond, and the restrictive influence that institutions exert on organizations will force organizations within the same institutional domain to converge. Greenwood’s (2011) recent research focuses on the differentiated institutional environment issues behind different corporate strategic behaviors, and further analyzes the impact of institutional complexity on corporate strategy <sup>[7]</sup>. Hoffman’s (1999) early research on institutional logic conflicts argued that when one logic dominates, institutional conflicts will essentially disappear <sup>[14]</sup>. Nigam & Ocasio (2010) believe that when external environmental conditions change, enterprises will change their dominant logic, evolve in a direction more conducive to their own development, and form a new institutional logic <sup>[15]</sup>.

The goal of institutional logic theory is to study and explore changes in different organizational fields and practices, on the one hand to study their complex mechanisms of action, and on the other hand to study their differentiated impacts. Early research on institutional logic mainly focused on the process of change and transformation. For example, for each organizational field, there will be the most mainstream institutional logic in different historical processes. The field level may undergo fundamental changes and transformations because it may be replaced by new institutional logics when it reaches the next historical stage, with representative works from Haveman *et al.* and so on <sup>[16]</sup>. By studying the milestones of different American companies analyze the logic of how different professional managers developed their companies in different periods. For example, different CEOs may, at different stages of enterprise development, emphasize manufacturing, marketing, and finally finance. The alternation of these two logics corresponds to the changing organizational methods of enterprises <sup>[17]</sup>. It analyzes how changes in the company’s institutional logic affect the succession of the company’s general manager. Scholars have studied some of the institutional logics of the American publishing industry. They first shifted from elite editor-centered institutional logic to market share-centered institutional logic, and explained how this shift affects the selection of successors.

In the subsequent theoretical development, Greenwood *et al.* proposed a new concept of institutions and pointed out that there will be opposition and conflicts between multiple coexisting institutional logics, which

is the “complexity” of institutions <sup>[7]</sup>. Lounsbury’s study reveals the opposition and conflicts between multiple coexisting institutional logics within the mutual fund industry, particularly highlighting the contrasting trustee and performance logics rooted in Boston and New York, respectively <sup>[18]</sup>. First is trustee logic, which emphasizes passive investing strategies and prioritizes low-cost money management. The second is performance logic, underscoring the importance of outperforming competitors through higher short-term annualized returns. The coexistence of these two logics creates a dynamic tension within the industry, influencing decision-making, strategy formulation, and the diffusion of practices among mutual funds. Funds aligned with the trustee logic might resist adopting practices that are perceived to increase risk, while those influenced by the performance logic might prioritize innovative strategies to enhance returns. The institutional logic dynamics herein challenges the traditional two-stage model of institutional diffusion by demonstrating how multiple forms of rationality can coexist and shape the evolution of organizational fields.

In another study by Dunn, similar institutional logic conflicts appears between care and science logics, the persistence over time, and their dynamic interplay on the education and training of future medical professionals <sup>[6]</sup>. The care logic emphasizes empathy, patient-centeredness, and the holistic treatment of patients, whereas the science logic prioritizes technological advancements, research, and evidence-based medicine. Several factors contribute to the tension and competition between these logics. Jurisdictional competition with proximate fields such as public health and the augmented influx of women into medical schools are associated with an intensified focus on the care logic. In contrast, the differentiation in the missions of medical schools may precipitate a diminished emphasis on the science logic. This dynamic interplay reflects the complex forces shaping the priorities and orientations within the medical educational sphere.

By studying core institutions with different cultures, such as countries, companies, churches, and families, scholars have found that culture is one of the causes of differences and conflicts in organizational practices. By comparing stock exchanges in different countries, it was concluded that there may be a competitive relationship between the government and professional financial practitioners, and the policy implementation of the Securities Regulatory Commission will also be affected by these economic professionals. Therefore, the conclusion is that there is a negative correlation between the state’s administrative capabilities and the protection of the rights and interests of small and medium-sized shareholders. Through research on family businesses, it was found that family members will crowd out professional managers.

### **3.2. Institutional logic in entrepreneurship**

When social actors legally conform to established social logics, deviant behavior will be punished by the audience. The behavioral hypothesis of market category theory is about the distinction between compliance and deviation. Due to awareness of punishment, entrepreneurs often use recognized models to explain and guide their actions when creating new products. This is a process of identity recognition. Actors’ specialized production within a category and cross-category production will affect the audience’s acceptance. Paolella and Durand concluded that there are prospects for the integration of market category and institutional logic theories <sup>[8]</sup>.

When faced with environmental complexity, resource dependence theory and institutional logic can establish a connection. For example, Pfeffer’s resource dependence theory treats the environment as a collection of organizations and focuses on the interdependence of resources between organizations and how power is generated <sup>[19]</sup>. Wry *et al.* concluded that institutional logic theory focuses on macro-level institutional logic and is a theory of organizational environment that can guide organizational cognition and norms, thereby affecting practice <sup>[20]</sup>.

The differences and conflicts between two or more institutional logics and found that the disagreements may be potential entrepreneurial opportunities. Pahnke *et al.* conducted an empirical analysis using data from the medical device industry<sup>[21]</sup>. The study found that corporate strategic investors, venture capitalists, and government investors in the United States have different institutional logics due to their different statuses and systems. Therefore, for the invested companies, the company's technical direction and business model will have completely different impacts. Individuals or organizations possess the capacity to transfer and apply extant knowledge and experiences derived from mainstream institutional logic to novel institutional contexts. This process, facilitated through hybrid reorganization, is underpinned by the theoretical constructs of institutional logic theory.

Tracey *et al.* cited the case of how the mainstream organizational form entrepreneurial incubator strived for category legitimacy, and finally optimized the category and defined competitive advantages<sup>[22]</sup>. Reay and Hinings studied the institutional logic of a medical institution in a certain region and found that the institution shifted from professional logic to market logic<sup>[23]</sup>. North believes that institutions are artificially designed to constrain people's behavior in the process of social interaction<sup>[2]</sup>. As a lasting social structure, it includes three elements: cultural cognition, formativeness, and coercion. Ault posits that organizational behavior, when influenced by market logic, prioritizes the evaluation of costs and benefits associated with corporate actions, positioning profit maximization as the paramount objective of the corporation<sup>[24]</sup>. When institutional pressure becomes an irreversible force, it will promote organizational adoption, which reflects the irrationality of the market. If enterprises face strict scrutiny of social logic, it will bring greater pressure to the realization of their market logic.

Changes in organizational fields and institutional complexity can be explained by elucidating the theory of institutional logic. Culture is the source of conflicts between different institutional logics. Individuals or organizations can also redefine and restructure culture to avoid conflicts and meet interests and goals. Institutional logic theory explores the institutional logic of society, industry, community, and other fields, and how it affects the cognition and decision-making of individuals or organizations. For example, Lounsbury and Glynn analyzed how entrepreneurs convey different cultural institutional logic by telling stories in different situations to build the company's legitimacy. In this process, it can be seen that entrepreneurs serve as the starting point for cultural logic, and experienced cultural operators have the ability to promote the essence and potential of enterprises to external audiences in different situations.

Previous research on entrepreneurial cognition was usually limited to cognitive assumptions about entrepreneurs, investors, and the psychological levels of entrepreneurs. Martens *et al.* conducted a qualitative analysis of Internet company prospectuses through large sample testing, and confirmed that mainstream institutional logic can indeed help entrepreneurs obtain external financing<sup>[25]</sup>. When stereotypes and cognitive biases exist between entrepreneurs and their evaluators, social logic prevails on the social root of the entrepreneurs, which facilitates their interaction with investors if aligned.

Through institutional logic, the study of stereotypes of female entrepreneurs and the corresponding social and demographic logic could be further explored, which may be inconsistent with the pursuit of high-risk male entrepreneurial roles. The characteristics of male entrepreneurs are more consistent with the role of entrepreneurs. Gender logic has had an important impact on the way entrepreneurs and investors perceive themselves, with underestimation on entrepreneurial motivation and performance due to gender logic. Institutional logic and opened up new horizons for gender role coordination theory. Within the domain of entrepreneurship, two prevailing institutional logics, social impact and business sustainability, play a pivotal role. Investors exhibit a preference for female entrepreneurs who engage in philanthropic endeavors and articulate statements of social impact. This



assertion highlights the influence of institutional logics at both social and organizational levels, suggesting that these logics extend cognitive and behavioral guidance to both individuals and organizations alike.

### **3.2.1. Institutional logic and entrepreneurial teams**

Wry *et al.* analyzed the process of consensus reached by entrepreneurial teams and pointed out that new entrepreneurial teams need to constantly tell clear stories within the team that can be collectively recognized <sup>[20]</sup>. This study shows that expansion of corporate members can occur in a coordinated rather than conflicting manner. Bertholdt & Olivier is one of the first scholars to propose new institutionalism logic for management <sup>[26]</sup>. The embeddedness of actors and the structuring and institutionalization processes of organizational fields, respectively.

The replacement of old and new institutional logics is not only the result of mutual promotion between institutional entrepreneurs, but also creates more opportunities for institutional entrepreneurs. Durand *et al.* conducted a study of the French design industry to explore why entrepreneurs who benefit most from their businesses often initiate institutional changes <sup>[27]</sup>. Jain and Sharma's qualitative study of the Indian telephone industry show that transformational logics are the result of different factions of institutional entrepreneurs pushing each other <sup>[28]</sup>. The emergence of new institutional logics does not instantaneously ascend to predominance; rather, they gradually catalyze institutional transformation. The advent of new market logics, which necessitate the identification and exploitation of opportunities, demands a temporal process and cannot be instantaneously actualized. This dynamic underscore the intricate process of institutional change, where new logics incrementally influence and reshape industry standards and practices.

The viewpoint of market logic by original elite class could be quite diverge from emerging new regulatory classes, which influenced and changed the institutional environment, and through the internal and external cooperation of reformers within the system, ultimately promoted legislation to the top and established the logic of the new market. Through research on China's photovoltaic industry that the establishment of new organizational forms provides entry conditions for latecomers, but the original experiences from precedence offered lessons and mindset for emerging peers.

Hybrid organizations embody multiple institutional logics at the same time, which could be dangerous, especially for startups. by Battilana and Dorado found that balance between the profitability and the social responsibility logic should be maintained for microfinance organizations <sup>[29]</sup>. External factors, such as employment policy could also be imperative for hybrid organizations. Almandoz studied the formation and dissolution of founding teams of major U.S. banks, which emphasizes the impact of founders by community logic by diverse backgrounds and cognization. This kind of hybrid organization that embodies multiple logics is easier to establish in times of economic stability, but more likely to go bankrupt and disband in times of economic instability. Almandoz further found that team size moderates the impact of institutional logic. In large teams, institutional logic could have influences on everyone in the team, even if they are more wedded to their own logic than to adhering to collective management logic <sup>[30]</sup>. Because in a team, responsibilities are less centralized, individual decisions are less likely to influence team decisions. Team members know each other well and are not easily influenced.

### **3.2.2. The impact of institutional logic theory on hybrid organizations**

Institutional logic theory should provide hybrid organization researchers with strategies for complex institutions and complex contexts. If the market logic of a country is strong, the business capital of microfinance institutions



investing in that country will increase. However, if the country's religious logic is complex, it will weaken the positive impact of market logic on financing and have a negative impact on the country's business capital investment. The complex mechanism of this system through a study of socially responsible funds. The purpose of a socially responsible fund is to maximize profits, which is its financial logic. On the other hand, it also has social welfare objectives. This is a classic example of a hybrid organization.

Zhao and Lounsbury studied the relationship between religious institutional logic and market logic through the financing sources of microfinance organizations<sup>[31]</sup>. Since microfinance organizations pursue profits on the one hand and eliminate inequality in developing countries on the other, they are also typical hybrid organizations. They find that market logic is positively related to the capital of microfinance organizations. Pache and Santos (2010) pointed out the distribution of groups representing different logics within the organization, and the requirements of different institutional logics for organizational legitimacy<sup>[5]</sup>.

In the past, it was more common to study how entrepreneurs and their firms respond to institutional pressures by one institutional factor. Institutional logic theory allows multiple logics to jointly influence the thinking and behavior of firms and business owners, which is very suitable for the national conditions of developing countries. Some of its coping strategies are decoupled, and some are not necessarily decoupled, which requires in-depth exploration. Luo *et al.* attempts to explore the reason why entrepreneurs and their companies adopt certain strategies and management and their effects<sup>[9]</sup>. The research focuses on looking for decoupling and paradoxes in the preceding and following stages, which are often attributed to certain institutional logics or conflicts within different mechanisms. After introducing the institutional complexity emphasized by institutional logic theory, decoupling is not the only strategy to deal with institutional logics complexity. Classification of organizational coping strategies from passive resistance to active manipulation when dealing with multiple and complex legitimacy pressures in the environment. Pache and Santos further proposed that attention should be paid to the political process within the organization<sup>[5]</sup>. For example, the distribution of groups with different logics, and specifically proposal on a series of strategies from negative to positive to deal with complex conflict logics such as acquiescence, compromise, avoidance, disobedience, and manipulation.

## 4. Discussion

Institutional logic theory offers a robust framework for examining the behaviors of organizational decision-makers, including entrepreneurs and business owners. Despite the substantial body of research dedicated to institutional logic theory, it remains a burgeoning area within organizational theory on the influence of institutional logic within the realm of small and medium-sized enterprises. Its vitality is attributed to the potential for interdisciplinary integration and applicability across a diverse array of domains. Future researchers need to study entrepreneurs more closely and conduct more in-depth research on the evolution of organizational coping strategies during political and cultural conflicts between different groups within a business. Study a series of response strategies and institutional conditions adopted by enterprises in response to multiple complex institutional logic environments. Especially in the field of entrepreneurship research, except for institutional entrepreneurs and hybrid organizations, there are relatively few empirical studies based on this theoretical perspective, which deserves vigorous development by researchers.

## 5. Conclusion

The article reviews the institutional logic theory through a literature review and discusses the necessity and key issues of applying this theory to entrepreneurship. The review also attempts to explore potential suggestions for entrepreneurs and their enterprises through the theory of institutional logic. First of all, based on the institutional logic theory, the country's core institutions include the state, market, family, company, professionals, religion, etc. There are conflicts between these aspects, but the logic of each system is highly interdependent. Secondly, institutional logic theory distinguishes itself from the foundational premises of neo-institutionalism at the level of the field. This allows researchers to integrate institutional logic into entrepreneurs' personal background, experience and other social characteristics and study how institutional logic operates.

The theory of institutional logic spans organizational fields and personal cognitive categories, and is specifically implemented into the social experience of entrepreneurs. Policy logic refers to the combination of a series of policies and tools adopted by the government to promote the upgrading of small and medium-sized enterprise entrepreneurship to specialization and innovation, including service supply and industrial policy guidance. For example, in real scenarios, diversified entities such as government-led scientific research institutes, financial institutions, and industry leaders provide enterprises with industrial foundations and investment and financing supply and demand connections. In addition, there are also social public services such as the establishment of industry-university-research cooperation platforms to help companies obtain operational and knowledge resources and ensure that companies understand industry market trends in a timely manner. On the one hand, government special innovation funds can directly reduce corporate R&D costs and risks. On the other hand, invested enterprises can also attract investment from investment institutions and other social capital by releasing signals of growth advantages. Government investment in innovation can reduce the negative externalities that may be brought about by corporate innovation. At the same time, by influencing the input of factor resources, we constantly update technology, spawn new products, and drive the upstream and downstream of the industrial chain by optimizing the industrial structure. Furthermore, the level of a country or region's digital economy may significantly impact a business's ability to access and manipulate data, causing organizations to view decoupling as more than just a strategy to deal with external legitimacy pressures.

Overall, institutional logic in the field of entrepreneurship could be complex, with potentially multiple logics entangling and interacting with each other. The consequences of institutional logics within the organization may also be impacted by the logics governing the overall society, such as the cultural, demographic and region logics. Furthermore, the logics governing the entrepreneurs themselves and their team members could also be significant. Institutional logics in certain industry, such as finance and education, has more current studies with more studies needed in other fields. Additionally, more focal studies on institutional logics of small and middle enterprises and the impact of social logics with vertical and horizontal comparisons may be needed for deeper understanding the evaluation of entrepreneurship institutional logic in depth.

## Disclosure statement

The author declares no conflict of interest.

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# Research on Digital Inclusive Finance Empowering the Development of Liaoning's Marine Economy

Xingye Chen\*

Liaoning University of International Business and Economics, Dalian, Liaoning, China

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**Abstract:** This article focuses on how digital inclusive finance empowers the development of Liaoning's marine economy. The research shows that while digital inclusive finance in Liaoning Province has grown rapidly in recent years, it still faces shortcomings in usage depth and coverage breadth. At present, digital inclusive finance has a significant empowering effect on Liaoning's marine economy, but challenges remain, including insufficient coverage and limited application of infrastructure, imperfect data governance and risk control systems for the marine economy, and a mismatch between digital financial products and the needs of the marine industry. To address these issues, the article proposes optimized pathways for digital inclusive finance to support Liaoning's marine economy: improving digital financial infrastructure to enhance service accessibility and efficiency; strengthening marine economic data governance to build an intelligent risk control system; innovating digital financial products to better align with industrial demands.

**Keywords:** Digital inclusive finance; Marine economy; Liaoning economy

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## 1. Introduction

Nowadays, the marine economy has become a key driver for empowering the sustainable growth of China's economy. Liaoning Province, with its strategic location along the Bohai Sea and the Yellow Sea, boasts a marine functional zone of 41,300 square kilometers and 633 islands, endowed with abundant marine resources. It has achieved remarkable success in fisheries, marine equipment manufacturing, port operations, and other fields. In the process of marine economic development, the role of financial services has become increasingly vital. Marine economic industries are often characterized by large investment scales, long payback periods, and high risks, which pose challenges to traditional financial service models.

Leveraging cutting-edge technologies such as big data, cloud computing, and the Internet, digital inclusive finance provides innovative solutions to address the financial challenges in the development of the marine economy. Its advantages in transcending geographical and temporal constraints, reducing service costs, and enhancing financial service accessibility, demonstrate tremendous application value in the marine economy sector.



At present, scholars have employed diverse methodologies to investigate how digital inclusive finance empowers the marine economy. Shuhong Wang demonstrated the enhancing effect of financial development on marine industrial productivity. Jian Lingxiang and others revealed the positive impact of the digital economy on the development of China's marine industry through random forest algorithms and partial effect models.

This article analyzes the current status and challenges of digital inclusive finance inempowering Liaoning's marine economy while exploring optimization pathways. It enriches the academic achievements in the fields of digital inclusive finance and the marine economy, and also provides a reference for marine industry practitioners to utilize digital financial resources.<sup>[1]</sup>

## **2. Mechanism Analysis of Digital Inclusive Finance Empowering the Marine Economy**

### **2.1 Broaden Financing Channels and Improve Risk Sharing Mechanisms**

Under traditional financial models, projects such as deep-sea aquaculture facilities construction often struggle to secure financing due to information asymmetry. Digital inclusive finance breaks through conventional limitations by leveraging technologies such as big data and the Internet, and reaches a broader range of entities through online platforms. This enables some small and medium-sizedmarine enterprises and individual aquaculturists who previously failed to meet standard requirements to obtain financing opportunities. Moreover, beyond traditional bank funding, digital inclusive financial platforms have also attracted internet financial institutions, private capital and others to participate in marine investment.

To address risks confronting the marine economy, including natural disasters and operational accidents, digital inclusive finance enhances the risk resilience by establishing multi-stakeholder mechanisms. Insurance institutions can develop diversified marine insurance products; while inclusive finance platforms may integrate upstream and downstream industry chain data to establish supply chain finance models. Under such frameworks, core enterprises collaborate with financial institutions to provide financing services for small and medium - sized enterprises across the supply chain, enabling rational risk distribution within the industrial ecosystem.<sup>[2]</sup>

### **2.2 Reduce Costs in Service Provision**

Marine economic activities involve extensive manual field surveys. Taking ocean - going fishing enterprises as an example, financial institutions need to conduct on - site verification of vessel assets and fishing operations. Relying on Internet technology, digital inclusive finance enables online financial service delivery, providing cost-efficient solutions for marine economy participants while enhancing operational efficiency.

### **2.3 Facilitate Industrial Transition toward Advanced Production Modes**

The marine economy is at a critical juncture of transformation and upgrading, requiring technological innovation and business model diversification. Financial institutions can launch digital inclusive financial products such as intellectual property pledge loans and scientific and technological achievement transformation loans to foster emerging industries such as marine biopharmaceuticals and ocean renewable energy. Furthermore, digital inclusive finance also supports the development of new formats including marine tourism and marine cultural creativity, providing an innovative impetus for industrial structure advancement in the marine economy.<sup>[3]</sup>

### 3. Development Status of Digital Inclusive Finance and Marine Economy in Liaoning Province

According to the “Peking University Digital Inclusive Finance Index” compiled by the Institute of Digital Finance at Peking University, Liaoning Province has experienced rapid development in digital inclusive finance over the past decade, with the aggregate index surging by 653.73%. A deeper analysis reveals that the growth rate of digitalization level significantly outpaced the expansion in service coverage breadth, usage depth, and the overall index **Table 1**.

**Table 1** Digital Inclusive Finance Index of Liaoning Province(2011-2020)

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Overall Index	43.29	103.53	160.07	187.61	226.4	231.41	267.18	290.95	311.01	326.29
Coverage breadth	44.96	89.01	126.67	175.49	194.17	207.74	239.87	271.81	292.44	307.11
Usage depth	44.64	120.36	181.54	162.89	178.41	220.06	291.27	279.48	302.52	328.12
Digitalization level	35.33	120.91	231.33	272.53	420.06	330.21	313.57	375.01	387.77	386.33

A comparative analysis between Liaoning and China’s leading marine economies—Guangdong, Shandong, and Shanghai—reveals that the most pressing enhancement requirement lies in usage depth, followed by coverage breadth **Table 2**.

**Table 2** Digital Inclusive Finance Index of Liaoning Province(2020)

Administrative region	Liaoning	Guangdong	Shandong	Shanghai
Overall Index	326.29	379.53	347.81	431.93
Coverage breadth	307.11	356.94	331.66	395.20
Usage depth	328.12	404.35	343.49	488.68
Digitalization level	386.33	409.06	409.00	450.08

In 2023, Liaoning’s marine industry achieved a total output value of 490.52 billion yuan, marking a 5.4% year-on-year growth. The six coastal cities, leveraging their own endowment advantages, have injected strong momentum into marine economic development. The Dalian Central Sub-branch of the People’s Bank of China has introduced pivotal policies including: “Guidelines on Financial Support for High-Quality Development of the Marine Economy” and the “Implementation Plan for Building Changhai County as a Pilot Zone for Inclusive Finance Ecosystem “. These measures aim to guide financial institutions in enhancing the supply of inclusive financial products.<sup>[4]</sup>

China Construction Bank Dalian Branch has launched the “Floating Raft Aquaculture” inclusive credit loan tailored for Changhai County’s industrial characteristics. By accepting sea area use rights as collateral, this product effectively resolves financing difficulties faced by oyster farmers lacking traditional collateral. Up to now, the “Floating Raft Aquaculture Loan” has been extended to 7 households with a total issuance of 2.2 million yuan. Upon maturation of the Changhai County pilot, the product will be rolled out across the entire Dalian city. Following the launch of “Aquaculture e-Loan - Sea Cucumber Loan”, Industrial and Commercial Bank of China Dalian Branch strategically expanded services in the second quarter of 2025 to include signature

marine farming species such as oysters and scallops in Changhai County, disbursing more than 36 million yuan in loans to 30 local aquaculture operators.

Since the beginning of this year, Postal Savings Bank of China Huludao Branch has disbursed cumulative loans exceeding 26 million yuan to 11 fishing households. At the Zhongshun Jellyfish Trading Market in Gaizhou, Yingkou, Postal Savings Bank of China Yingkou Branch facilitates merchant financing through its specialized “Jellyfish Cash Flow Loan” and “Jellyfish Industry Chain Loan” products. In Donggang, Dandong, Postal Savings Bank of China provide tailored services for the “variegated clam” industry, including door to door financial services and bulk credit approvals. For Dalian’s sea cucumber industry, Postal Savings Bank of China has launched salted sea cucumber pledge loans, with core enterprises acting as supervisors and disposers to conduct joint supervision with the bank. A third-party evaluation agency is introduced for valuation, and loans are granted at 50% of the valuation price.

In addition, digital inclusive finance has also played a pivotal role in the financing of marine economic enterprises. Since 2024, 27 marine and port enterprises in Liaoning Province, including port-related listed companies, have raised over 30 billion yuan through bond issuances.<sup>[5]</sup>

## **4. Challenges in Digital Finance’s Empowerment of Liaoning’s Marine Economy Development**

Liaoning Province still faces multiple challenges in leveraging digital inclusive finance to empower the development of the marine economy.

### **4.1 Inadequate Coverage and Restricted Application of Digital Financial Infrastructure**

Marine economic entities are predominantly distributed across coastal counties and islands such as Changhai County and Zhangzi Island, where remote locations and unstable fishing village network coverage impair digital financial service delivery. At the same time, Digital literacy disparities among marine economic actors persist, with older fishermen demonstrating particularly low adoption rates for online identity verification and e-contract signing processes. This creates enduring barriers to digital financial product accessibility. Inadequate comprehension of online credit products’ eligibility criteria and repayment terms constrains the outreach efficiency of digital financial services.

### **4.2 Inadequate Data Governance and Underdeveloped Risk Control Systems for the Marine Economy**

Liaoning’s marine industries involves multiple fields such as fishery, ports, shipbuilding, and meteorology. Relevant data are scattered in different departments such as agriculture, maritime affairs, and meteorology, with inconsistent data standards and an imperfect sharing mechanism. There is no electronic ledger for data such as fishermen’s catch volumes, aquaculture areas, and seafood transaction records, preventing financial institutions from validating big data models. Meanwhile, existing risk control models demonstrate inadequate capacity to quantify marine economy exposures, particularly ecological-environmental hazards and operational safety threats. Financial institutions still predominantly rely on manual due diligence when extending credit to marine industries, with inadequate utilization of critical oceanographic data such as sea surface temperature anomalies and current patterns, resulting in suboptimal risk assessment model accuracy.

### **4.3 Poor Alignment between Digital Financial Products and Marine Industry Needs**

The fishing industry's seasonal characteristics—such as spring seedling cultivation and autumn fishing—require substantial short-term financing at critical junctures. However, most existing financial products enforce fixed repayment schedules, failing to accommodate its “lump-sum expenditure, staggered revenue” cash flow pattern. Industries such as marine equipment manufacturing and marine biomedicine are technology-intensive sectors characterized by long R&D cycles and heavy capital investment. Their core assets mainly consist of specialized equipment or intellectual property rights, while traditional digital credit products still primarily rely on fixed asset mortgages, and the evaluation system for intangible assets remains underdeveloped. In addition, marine tourism is highly susceptible to weather conditions, policy changes, and other external factors, resulting in elevated operational risks. However, traditional digital credit products still primarily rely on fixed-asset mortgages, and the evaluation system for intangible assets remains underdeveloped.

## **5. Countermeasures for Digital Finance to Empower the Marine Economy Development in Liaoning Province**

### **5.1 Optimize Digital Financial Infrastructure and Enhance Service Accessibility Efficiency**

Increase investment in network coverage for coastal counties and island areas, extending 5G base stations to fishing villages and fishing ports to improve maritime signal quality. At the same time, leverage the digital rural development initiative to deploy self-service financial service terminals at fishery cooperatives, offering digital services such as loan applications and insurance enrollment. Financial institutions should organize “Digital Finance into Fishing Villages” campaigns, using case studies and live demonstrations to educate fishermen on utilizing digital financial services. Illustrated user guides should be distributed, and training sessions should be conducted during fishing off-seasons when vessels are docked. In addition, financial institutions may develop marine-adapted streamlined digital finance products, such as voice-interactive loan application interfaces and offline contract signing capabilities to significantly improve the practical accessibility of digital financial services.

### **5.2 Enhance Data Governance for Marine Economy and Establish a Risk Control Framework**

Establish a governance system centered on “data integration - model optimization - risk early warning”. Establish a government-led “Marine Economic Data Sharing Platform” to break down data barriers between different departments and unify data standards. At the same time, promote the digitization of fishermen's production data, support fishery cooperatives in establishing electronic record systems to achieve traceable operational information.

Enhance quantitative assessment of marine-specific risks. Financial institutions should collaborate with marine research institutes to develop risk evaluation models, incorporating data such as seawater temperature variations, ocean current patterns, port throughput volumes, and international seafood prices into model parameters. In addition, for critical data including fishermen's credit records and vessel mortgage information, authenticity must be rigorously verified. For high-risk credit operations, a dual-layer risk control mechanism combining automated data verification with manual review shall be implemented..

### 5.3 Innovate Digital Financial Products and Enhance Industrial Adaptability

In response to the seasonal characteristics of marine fishery, financial institutions may develop flexible credit products featuring “quarterly interest payments with principal repayment during the harvest period”; for technology-intensive enterprises such as marine equipment manufacturing and biomedicine, optimize intangible asset valuation systems, incorporate indicators such as patent conversion rate and technology maturity into the risk control dimension, and promote intellectual property pledge financing. To strengthen risk protection, it is essential to expand the coverage and customization of insurance, encourage insurance companies to develop specialized coverage products that integrate storm classification data with automated claims mechanisms to enable rapid payouts. For marine tourism operators, introduce business interruption insurance to cover losses from unforeseen risks.

## 6. Conclusion

Digital inclusive finance has served as a crucial enabler for Liaoning’s marine economy development. Through mechanisms such as broadening financing channels, reducing transaction costs, and promoting industrial innovation, it has achieved remarkable results in helping the transformation and upgrading of the marine industry. However, it still faces constraints such as inadequate digital infrastructure, data governance gaps and product-market mismatch. By enhancing digital infrastructure, optimizing data sharing mechanisms, and innovating customized financial products, the enabling effect of Liaoning’s digital inclusive finance on the marine economy can be further released. In the future, Liaoning Province should capitalize on emerging opportunities to optimize the financial ecology continuously, enhance government-industry-university-research collaboration to propel the Liaoning’s marine economy to new heights.

## Disclosure statement

The author declares no conflict of interest.

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# The Origin, Measurement, and Influencing Factors of Enterprise Resilience

Yu Shen\*

Nanjing University of Science and Technology ZiJin College, Nanjing 210023, Jiangsu, China

*\*Author to whom correspondence should be addressed.*

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**Abstract:** In the dual context of VUCA era and digital transformation, enterprise resilience, as the core ability of organizations to resist shocks, adapt to changes, and achieve sustainable development, has increasingly highlighted its theoretical connotation and practical value. This article systematically explores the interdisciplinary theoretical origins, multidimensional dynamic measurement methods, and complex influencing factors of enterprise resilience. Research has shown that: (1) the concept of resilience originates from ecology, engineering, and physics, and extends to the field of complex adaptive systems, forming a micro capability integration framework of “pre crisis prevention crisis response crisis recovery”, as well as macro strategic attributes that support high-quality development of the national economy; (2) Resilience measurement needs to integrate subjective and objective dynamic indicators: at the subjective level, Likert scale is used to evaluate organizational capability traits, and at the objective level, financial performance fluctuations, market performance, and crisis learning behavior are combined; (3) Resilience is driven by the synergy of multiple levels of factors: internal dependence on organizational capability foundation, digital empowerment, external resource linkage, policy environment, and sustainable governance. Its interaction mechanism accelerates capability updates through digital iteration, policy activates resource networks, and ultimately constructs an organizational resilience system of “survival adaptation evolution”. This article provides a unified analytical framework for the study of enterprise resilience, and provides theoretical guidance and practical paths for organizations in the digital age to cultivate risk resistance capabilities and achieve resilience evolution.

**Keywords:** Enterprise resilience; Digital empowerment; Influencing factors; Sustainable governance

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## 1. Introduction

In the context of VUCA (volatility, uncertainty, complexity, and ambiguity) era, macroeconomic fluctuations and micro enterprise survival environment are facing unprecedented challenges. Enterprise Resilience, as the core ability of organizations to resist shocks, adapt to changes, and achieve sustainable development, has become a focus of attention for both academia and practice. Although this concept originated from ecology<sup>[1]</sup> and engineering<sup>[2]</sup> and is manifested in physics as the “toughness” characteristic of fracture resistance<sup>[3]</sup>, its theoretical connotation has extended to interdisciplinary fields of complex systems, becoming an inherent property of enterprises, infrastructure

and other systems to cope with disturbances<sup>[4,5]</sup>. Although Meyer (1982) was the first to introduce resilience into business management research, there is still disagreement in academia regarding its definition: at the micro level, it focuses on the integration of dynamic capabilities before, during, and after a crisis<sup>[6-8]</sup>, while at the macro level, it emphasizes its strategic value for the high-quality development and sustainability of the national economy<sup>[9]</sup>. Especially in the global wave of digital transformation, enterprise resilience has been endowed with new connotations - the ability to use digital technology to identify environmental changes, prevent crises, respond efficiently, and achieve long-term development adaptability<sup>[10]</sup>. However, existing research has not yet systematically addressed three key issues: firstly, the lack of integration of interdisciplinary theoretical origins weakens the essential understanding of resilience as a dynamic capability; Secondly, the measurement methods are fragmented, and the isolated use of subjective scales, market indicators, and financial performance makes it difficult to capture the multidimensional dynamic characteristics of resilience<sup>[11]</sup>; Thirdly, research on influencing factors is scattered across dimensions such as organizational capacity, digitization, external resources, and sustainable governance, lacking a systematic deconstruction of their interaction mechanisms. Therefore, based on the background of the digital age, this article clarifies the theoretical origins of resilience, constructs a measurement system of “subjective and objective combination+dynamic process”, and reveals the synergistic mechanism of organizational capability foundation, external resource network, and policy environment. The aim is to provide a unified analytical framework for enterprise resilience research and provide theoretical guidance for the practice of cultivating risk resistance and achieving sustainable evolution.

## 2. Research on enterprise resilience

### 2.1. The origin and definition of resilience

In the era of VUCA, the importance of resilience in macroeconomic operations and micro enterprise development is increasingly prominent, receiving widespread attention from the academic community. As shown in **Table 1**, Resilience “originated in the field of ecology and refers to the ability of ecosystems to absorb and respond to disturbances<sup>[1]</sup>. In addition to its widespread application in ecology, the concept of resilience is becoming increasingly important for engineering systems as it is a method of solving their increasingly complex problems and designing systems that can sustain unexpected failures without catastrophic losses. For engineering systems, resilience is defined as the ability of the system to withstand disturbances and recover while undergoing changes and maintaining the same functionality<sup>[2]</sup>. From a physics perspective, the stronger the toughness, the less likely brittle fracture occurs<sup>[3]</sup>. Resilience, as a key concept, also appears in interdisciplinary fields related to complex systems, such as enterprises, critical infrastructure systems, and ecosystems<sup>[4,13]</sup>. From these perspectives, resilience is referred to as an inherent property of complex systems<sup>[1,13,5]</sup>. The perspectives defined by different disciplines are different, but a certain consensus has also been reached.

**Table 1.** The origin and definition of resilience

Discipline	Definition
Ecology	The ability of an ecosystem to absorb and respond to disturbances.
Engineering	The capacity of a system to withstand disturbances and recover while maintaining its original functions after experiencing changes.
Physics	The ability of a material to absorb energy during plastic deformation and fracture. Higher toughness reduces the likelihood of brittle fracture.
Interdisciplinary	Resilience constitutes a response to unexpected changes and disturbances, reflecting the ability to adapt to and cope with such disruptions. It is an inherent property of complex systems.

## 2.2. Main viewpoints on enterprise resilience

Professor Meyer (1982) was the first to bring resilience research into the field of enterprise management<sup>[6]</sup>, thus opening the curtain on the study of enterprise management resilience. However, so far, there is no consensus on the main theoretical content of research on enterprise resilience in the field of enterprise management. But overall, it can be defined from two perspectives: micro and macro. As shown in **Table 2**, macroscopically, it is a global and complete concept; At the micro level, it can be divided into three stages: pre event, in event, and post even. From a pre employment perspective, resilience is a potential capability foundation for enterprises, helping them predict external shocks, adjust and respond in a timely manner, and avoid further losses. It is an essential characteristic for enterprises to cope with crises or overcome difficulties<sup>[7,14]</sup>. This viewpoint tends to view corporate resilience as inherent resilience, that is, the ability under normal circumstances<sup>[13]</sup>. The mid-term stage focuses on highlighting the current response of the enterprise, that is, the enterprise continues to operate even when encountering significant disruptions, which can measure whether the enterprise has the ability to respond to crises<sup>[15,11,16]</sup>. The post event view suggests that even after a destructive crisis occurs, companies can still restructure and maintain their organizational status<sup>[8]</sup>, restoring inventory, production capacity, service efficiency, and other aspects to normal levels<sup>[17]</sup>.

In summary, at the micro level, enterprise resilience refers to the ability of a company to identify and scan internal and external environmental changes, prepare and take preventive measures to integrate internal and external resources, respond promptly and effectively to emergencies, achieve recovery, and possess the ability for long-term prosperity<sup>[18]</sup>. From a macro perspective, economic resilience is the key to measuring the high-quality development of a country's economy, which can ensure the sustainable development of the economy. Enterprise resilience has the same value<sup>[19]</sup>.

In summary, combined with the digital background, this article defines enterprise resilience as the adaptability of enterprises for long-term development, specifically manifested as the ability to use digital technology to respond to and overcome various crises in the development process. The ability of enterprises to identify external changes, fully prevent and prepare in advance, effectively respond and recover afterwards, and achieve long-term development.

**Table 2.** Main viewpoints on enterprise resilience

Perspective	Phase	Core view
Micro-level	Pre-disruption	The potential capability of enterprises to predict, avoid, and adjust to external shocks – an essential attribute for overcoming crises.
	During-disruption	The ability of enterprises to maintain continuous operations when facing major disruptions.
	Post-disruption	The capacity to reconfigure resources and sustain organizational functions after a crisis.
	Comprehensive	The integrated capability to identify external changes, proactively prepare, respond effectively, recover, and achieve long-term development.
Macro-level	Holistic	A key metric for high-quality national economic development and a safeguard for sustainable growth.

## 3. Measurement of enterprise resilience

Enterprise resilience is an important indicator for measuring the performance of enterprise development, and the measurement methods mainly include the following three methods, which is shown in **Table 3**: first, survey scale measurement. Lu *et al.*(2021) subjectively and objectively measured enterprise resilience, and the subjective measurement drew on the Likert scale to construct an indicator system; Objective measurement mainly measures

the recovery level and recovery time of enterprises after being subjected to destructive shocks<sup>[20]</sup>. It is believed that the shorter the recovery time and the higher the recovery level, the stronger the resilience of enterprise; The second is to focus on the market performance of enterprises, which focuses on examining the volatility, recovery level, and recovery time of stock prices of listed companies after being impacted. It is usually measured by the growth rate of stock returns, emphasizing that the recovery level of stock prices and their returns should not be lower than the level before the impact<sup>[11]</sup>; The third is to use the financial performance indicators of the enterprise to measure its resilience, including profitability, growth ability, debt paying ability, etc., such as return on equity, return on assets<sup>[12]</sup>, sales net profit margin, and the ability of operating income to recover growth after an impact, as well as indicators such as the growth rate of operating income from the perspective of enterprise performance<sup>[21]</sup>.

**Table 3.** Methods for measuring enterprise resilience

Approach	Medium	Perspective	Specific method
Direct	Scale-based Scale-based	Capability	Anticipatory, responsive, and adaptive capabilities
		Process	Monitoring, response, prediction, and learning
		Traits	Stability, sensitivity, and synergy
Indirect	Financial Metrics	Comprehensive Performance	Financial volatility, sales growth rate, survival rate
			Long-term growth and financial fluctuations
			Risk resistance, adaptive adjustment, and recovery capabilities
			Risk resistance, recovery adaptability, and innovation transformation capabilities
			Standard deviation of long-term ROE relative to industry peers
			Total sales revenue relative to industry average development level
	Market Metrics	Impact of External Shocks	Magnitude of stock price decline, duration of decline, and recovery extent
			Post-crisis stock price recovery extent
			Stock price volatility

#### 4. Factors influencing enterprise resilience

As shown in **Table 4**, the formation and development of enterprise resilience are influenced by multi-level complex factors, and its core is rooted in the internal capability foundation of the organization. Dynamic capabilities enable enterprises to quickly restructure resources and adjust strategies to respond to crises. The heterogeneity of the executive team, CEO openness, and internal social capital further strengthen this adaptability by enhancing decision-making diversity and internal collaboration efficiency<sup>[22]</sup>. Closely linked to this is digital empowerment, where digital transformation significantly enhances resilience by restructuring business processes and optimizing data-driven decision-making. The application of artificial intelligence deepens risk warning mechanisms, while digital supply chain management strengthens the responsiveness of the supply chain. However, caution should be taken against the efficiency inflection points that may arise from excessive digitization<sup>[23-25]</sup>.

The external resource linkage mechanism provides key support for enterprises to cope with external shocks, strategic alliance cooperation expands the boundaries of resource acquisition, state-owned capital participation enhances the stability of the industrial chain by fixing and supplementing the chain, while the agglomeration of productive service industries and the coordination of supply chain networks rely on specialized division of

labor to build elastic buffer spaces <sup>[36-38]</sup>. These synergies are amplified under the catalysis of policies and market environments: the construction of a unified national market reduces institutional transaction costs, innovative policies and new infrastructure provide technology and resource supply channels, and government assistance becomes a guarantee to resist extreme sanctions <sup>[29-31]</sup>.

Sustainable governance constitutes the long-term cornerstone of resilient development, ESG rating enhancement strengthens resilience by optimizing corporate reputation and risk management, and social responsibility fulfillment consolidates stakeholder support in most contexts, but resource constraints may weaken its positive effects; Carbon neutrality practices promote structural adaptation in green transformation, while patient capital provides stable long-term financial support for strategic adjustments <sup>[32-34]</sup>.

The above factors shape resilience through dynamic interaction: digital empowerment accelerates organizational capability iteration <sup>[35]</sup>, policy environment activates external resource networks <sup>[36]</sup>, and sustainable governance runs through the entire process of building internal and external resilience systems, ultimately forming the vitality of organizational survival, adaptation, and evolution <sup>[37]</sup>.

**Table 4.** Factors influencing enterprise resilience

Dimension	Influence factor	Influence direction
Fundamentals of organizational capability	dynamic capability	+
	Heterogeneity of senior management team	+
	CEO openness	+
	Risk-taking willingness	+
	Social capital within the organization	+
	Innovation resilience	+
Digital empowerment	Digital transformation	+/Inverted N-type
	Data element input	+
	Artificial intelligence application	+
	Digital supply chain management	+
External resource linkage	Strategic alliance cooperation	+
	State-owned capital equity participation	+
	Agglomeration of productive service industries	+
	Supply chain network collaboration	+
Policy and market environment	Construction of a unified national market	+
	Innovation policy support	+
	New infrastructure	+
	Government assistance	+
Sustainable governance	ESG rating improvement	+
	Fulfillment of social responsibility	+/-
	Carbon neutrality practice	+
	Patient capital investment	+



## 5. Conclusion and future prospects

This study systematically explores the complex and critical organizational capability of enterprise resilience, delving into its theoretical origins, scientific measurement methods, and multidimensional influencing factors. The conclusion indicates that the concept of enterprise resilience is rooted in multiple disciplinary fields, particularly ecology, complex adaptive system theory, and crisis management theory. This provides a solid theoretical foundation for understanding its essence as an organization's dynamic ability to absorb shocks, adapt to changes, and achieve recovery or even transcendence in turbulent environments. At the measurement level, research has revealed that enterprise resilience cannot be summarized in a single dimension. Effective measurement requires a combination of objective financial indicators and subjective perception indicator, as well as attention to the learning and change behaviors exhibited by organizations during crises, to construct a multidimensional and dynamic evaluation system. Regarding the influencing factors, research has found that corporate resilience is influenced by a complex interplay of multiple internal and external factors. Among the internal factors, robust organizational capita, deep social capita, and key psychological capital constitute the core pillars of resilience; In terms of external factors, the stability of the stakeholder network, the characteristics of the industrial environment, and the support of the macro institutional environment jointly shape the buffer zone and resource pool for enterprises to cope with external shocks. These factors do not exist in isolation, but interact and work together to determine the vulnerability and resilience of enterprises in the face of crises. Ultimately, this study confirms that enterprise resilience is a core capability for organizations to survive and develop in uncertain times, and its cultivation is a systematic project involving strategic foresight, structural optimization, cultural shaping, and relationship management.

Although this study has deepened our understanding of corporate resilience, there is still vast room for exploration in this field. Future research should focus on overcoming the limitations of existing measurement methods and developing resilience dynamic assessment tools that are more timely, forward-looking, and industry applicable, such as using big data and artificial intelligence technologies to track organizations' real-time response patterns and recovery trajectories in crises, and exploring methods for identifying resilience thresholds. At the same time, theoretical construction requires further integration of emerging perspectives, in-depth exploration of the micro psychological mechanisms underlying resilience formatio, dynamic process models of resilience evolution, and the interrelationships and transformation conditions between different resilience type. In terms of influencing factors, future work urgently needs to focus on resilience differences in specific contexts, such as in-depth analysis of the heterogeneity and prioritization of key resilience driving factors in different industries, different sized enterprise, and facing different types of shock. In addition, the revolutionary impact of digital technologies such as artificial intelligence, blockchain, and the Internet of Things on building enterprise resilience, particularly in enhancing situational awareness, optimizing decision-making speed, reshaping supply chain resilience, and innovating business models, is a highly relevant research frontier. Exploring effective intervention strategies and practical paths for cultivating resilience, such as how to design resilience oriented leadership development projects, build a learning oriented organizational culture, optimize crisis plans and exercise mechanisms, and how to create an external ecosystem that is more conducive to enterprise resilience growth through policy design, will be a key bridge connecting theory and practice in the future. Ultimately, the ultimate goal of research should be to help businesses not only "survive" in crises, but also achieve "evolution", transforming resilience into a source of sustainable competitive advantage, and contributing wisdom to building a more risk resistant business ecosystem and economic system.

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# Configurations for Xiamen-Zhangzhou-Quanzhou Regional Economic Integration--Based on Fuzzy Set Qualitative Comparative Analysis

Fan Zhang\*

Xiamen University Tan Kah Kee College, Zhangzhou 363123, Fujian, China

*\*Author to whom correspondence should be addressed.*

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**Abstract:** Achieving mutual benefits in the process of city cluster integration is the core of sustainable regional economic development. This means the core city is driving and avoids the siphon effect. Therefore, it is crucial to analyse which factors affect the differences in integration outcomes. In this paper, for the 28 districts and counties of Xiamen-Zhangzhou-Quanzhou City Cluster, we use FsQCA to analyse the configuration of the impacts of five conditions, namely, urbanization, infrastructure development, level of public services, degree of government intervention, and industrial structure, on the intensity of the districts and counties' economic linkages. This paper obtains four group conditions of high economic linkage intensity and seven paths leading to low economic linkage intensity. And in this regard, it puts forward suggestions such as constructing a mechanism for coordinated development of regional industries and accelerating the convenient sharing of public services.

**Keywords:** Regional economy; Xiamen-Zhangzhou-Quanzhou metropolitan area; FSQCA

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## 1. Introduction

Regional economic integration is one of the essential strategies for China's current economic development (Liu, 2014)<sup>[1]</sup>. Through economic integration, it can break the administrative division and geographical restriction, strengthen the connection and cooperation between cities in the region, optimize the allocation of resources, and promote the coordinated development of the regional economy (Liu et al., 2011<sup>[2]</sup>; Zhang et al., 2021)<sup>[3]</sup>. Zhangzhou, Xiamen, and Quanzhou are located on the southeast coast, known as the "Golden Triangle of Southern Fujian", and share the commonality of Minnan culture, constituting an essential urban agglomeration in the Southern Fujian region. At a high level of planning, Xiamen-Zhangzhou-Quanzhou regional integration has been vigorously promoted by policy. Since 2011, economic ties between the three cities have been strengthened, with the realization of co-location of communications, inter-city high-speed rail links, bus card integration in infrastructure, common protection of watersheds, and collaboration on pollution control in the environmental field.



Over the past decade, the three cities have gradually formed an organic pattern of regional economic integration. Still, the current speed of integration falls short of the expected process. The three cities of Xiamen, Zhangzhou, and Quanzhou are economically complementary. If resource sharing and complementary advantages are realized, the sustainable development of the regional economy will be better promoted.

The essence of regional economic integration is the integration and development within a complex system. The complex system is not simply how the independent variables (such as industrial structure, fiscal expenditure, policy strength) affect the dependent variable (the degree of economic integration). Instead, the configuration conditions play a role here. The relationship between the independent variables may be the key to explaining regional economic integration. This may also explain why existing studies show that city clusters may lead to different results at different stages of development and for various reasons; for example, in some cases of city cluster integration and development, it is shown that the core cities siphon off more than they radiate to the peripheral cities. In contrast, in other cases, the later cities can leverage the first cities to develop more rapidly.

Qualitative comparative analysis is based on Boolean algebra and set theory. It is usually used for cross-case comparative analyses of medium-sized samples to study the logical relationship between multiple conditions and outcomes. Fuzzy set qualitative comparative analysis (FSQCA) extends the original method and helps to understand complex cause and effect in real society (Du et al., 2017) <sup>[4]</sup>. Previously, there are no articles using qualitative comparative analysis in the research on Xiamen-Zhangzhou-Quanzhou regional economic integration, and this paper focus on the combination of conditions affecting Xiamen-Zhangzhou-Quanzhou regional economic integration. On the academic level, this paper will try to use qualitative comparative analysis for integration path research, thus enriching the framework of analytical tools for the regional economy.

In summary, this paper uses Fuzzy Set Qualitative Comparative Analysis (FsQCA) to analyse the combination of conditions affecting the regional economic integration of Xiamen-Zhangzhou-Quanzhou from the level of districts and counties of the cities. This paper begins with a review of the literature on the influencing factors of regional economic integration in Part II, followed by a general analysis of the current status of regional integration in Xiamen-Zhangzhou-Quanzhou; describes the selected conditional variables and data processing in Part III; carries out a fuzzy-set qualitative comparative analysis in Part IV; and concludes and puts forward relevant recommendations in Part V.

## **2. Literature Review and Current Situation Analysis**

### **2.1. Influencing Factors of Regional Economic Integration**

From the existing studies, it is known that there are differences in the degree of economic integration of Chinese urban agglomerations (Zhou et al., 2010 <sup>[5]</sup>; Wang et al., 2021) <sup>[6]</sup>, and many possible factors affect this integration (Chen, 2008 <sup>[7]</sup>; Cao et al., 2017) <sup>[8]</sup>. These factors can be classified into three aspects: policy, economy, and society.

In terms of policy, the higher-level government increases support for cross-regional cooperation, strengthens cooperation between city clusters, and promotes industrial transfer, which is conducive to the development of regional integration. However, the effect of policy implementation will affect the degree of integration (Peng, 2009 <sup>[9]</sup>; Ma, 2019 <sup>[10]</sup>).

On the economic front, factors such as industrial structure, capital flows, technological innovation, and infrastructure development may all affect regional economic integration, but their relationship with integration varies across different city clusters (Guo et al. 2016 <sup>[11]</sup>; Liu et al., 2020 <sup>[12]</sup>; Ma et al., 2022) <sup>[13]</sup>. It is usually

believed that urban economic growth and urbanization can promote regional integration by creating more market opportunities and increasing the gravitational value between cities; infrastructure development can reduce intra-regional trade costs; and rationalisation of industrial structure can promote regional integration more than advanced development. For example, Liu and Hu (2011) <sup>[2]</sup> found that the construction of transport infrastructure promotes regional economic integration by increasing the volume of inter-regional trade. Wang and Li (2018) found that urbanization in the Yangtze River Delta has a direct positive impact on regional economic growth <sup>[14]</sup>. Xie et al. (2021) find that upgrading industrial structure inhibits market integration development <sup>[15]</sup>.

On the social front, population mobility, cultural and educational exchanges, etc., also affect the sustainability of economic integration (Chen et al., 2009<sup>[16]</sup>; Cao et al., 2017<sup>[8]</sup>). Chen et al. (2009) empirically analyzed that the integration of entrepreneurial culture and the integration of risk-taking culture in the Yangtze River Delta region promotes economic integration. Liu and Yue (2020) found that the same language attribute in the integration process is a positive driving factor <sup>[12]</sup>. Moreover, the quality of basic public services affects the behavioral choices of enterprises and individuals, affecting the flow of talents and capital.

## 2.2. The current status of Xiamen-Zhangzhou-Quanzhou regional integration

This paper calculates the economic affiliation and gravitational force values for the years 2005, 2010, 2015, 2019, and 2022 using the gravitational force model to investigate the changes in mutual economic ties between the Xiamen-Zhangzhou-Quanzhou metropolitan area under policy impetus. The gravity model measures the strength of the interaction force between regions brought about by economic size and distance.

$$R_{ij} = k_{ij} \frac{(\sqrt{P_i \cdot G_i} \times \sqrt{P_j \cdot G_j})}{D_{ij}^2} \quad (1)$$

Where,  $R_{ij}$  is the strength of economic affiliation between two regions;  $P_i$ ,  $P_j$  is the total population of the area;  $G_i$ ,  $G_j$  is the GDP of the two cities;  $D_{ij}$  is the distance between the cities, and  $k$  is the correction coefficient, computed as the ratio of the  $GDP_i$  to the sum of the GDP of the two cities. Among them, the GDP and population data are from the Fujian Provincial Statistical Yearbook, and the inter-regional distance measure is from Gaode Map.

Tables 1-5 show that the gravitational value between Xiamen, Zhangzhou, and Quanzhou has increased. In contrast, the gap between Xiamen's gravitational value and Quanzhou's has widened from 2015 onwards, and Xiamen's core position in the Xia-Zhang-Quan metropolitan area has gradually been established. Furthermore, Zhangzhou is relatively weaker in terms of gravitational value. In terms of economic affiliation, relative to Quanzhou, Zhangzhou and Xiamen are getting closer to each other, exceeding 80% by 2022. However, the gravitational values of Xiamen and Zhangzhou are not symmetrical.

**Table 1** 2005 Xiamen-Zhangzhou-Quan Economic Affiliation and Gravity Value

	Zhangzhou	Xiamen	Quanzhou
Zhangzhou		68.59 %	45.26 %
Xiamen	72.54 %		54.74 %
Quanzhou	27.46%	31.41 %	
Gravitational value	38.08	64.48	59.78

**Table 2** 2010 Xiamen-Zhangzhou-Quanzhou Economic Affiliation and Gravity Value

	Zhangzhou	Xiamen	Quanzhou
Zhangzhou		68.57 %	40.44 %
Xiamen	76.26 %		59.56 %
Quanzhou	23.74 %	31.43 %	
Gravitational value	105.63	169.16	154.50

**Table 3** 2015 Xiamen, Zhangzhou-Quanzhou Economic Affiliation and Gravity Value

	Zhangzhou	Xiamen	Quanzhou
Zhangzhou		64.11 %	35.54 %
Xiamen	76.42 %		64.46%
Quanzhou	23.58 %	35.89 %	
Gravitational value	219.64	326.02	323.29

**Table 4** 2019 Xiamen-Zhangzhou-Quanzhou Economic Affiliation and Gravity Value

	Zhangzhou	Xiamen	Quanzhou
Zhangzhou		67.84 %	34.71 %
Xiamen	79.87 %		65.29 %
Quanzhou	20.13%	32.16 %	
Gravitational value	458.55	682.56	557.87

**Table 5** 2022 Xiamen-Zhangzhou-Quanzhou Economic Affiliation and Gravity Value

	Zhangzhou	Xiamen	Quanzhou
Zhangzhou		67.18 %	31.93 %
Xiamen	81.36 %		68.07 %
Quanzhou	18.64 %	32.82 %	
Gravitational value	594.05	983.67	735.51

Data source: The author's own calculation.

It is difficult to deeply analyze the degree of regional integration and influencing factors only from the city level of Xiamen-Zhangzhou-Quanzhou, therefore, combining the basic situation of Xiamen-Zhangzhou-Quanzhou districts and counties, this paper chooses the level of urbanization, infrastructure development, public service level, the degree of governmental intervention and industrial structure as the conditional variables, and conducts the configuration analysis using FsQCA. The interdependence of the cause conditions and the multiple concurrent causality constituted by different combinations are analyzed by QCA. Under the asymmetric assumption of QCA, the combinations of conditions that lead to high and low regional economic integration can be found separately.

### 3. Data, conditions and initial calibration

In this paper, we use 28 districts and counties of Xiamen, Zhangzhou, and Quanzhou<sup>[1]</sup> as the research objects. The relevant data are obtained through the statistical yearbooks of Fujian Province, Xiamen, Zhangzhou, and Quanzhou in 2022.

#### 3.1. Outcome variables

The outcome variable is each district and county's economic linkage intensity (YLZ). Using the above gravity model, this paper calculates the gravity value of each district and county under Zhangzhou, Xiamen, and Quanzhou in 2021 (as shown in Table 6).

**Table 6** Economic linkage intensity of districts and counties in 2021

District	Gravitational Value	Ranking	Region	Gravity Value	Ranking
Siming	4881.869	1	Longwen	289.4323	15
Jinjiang	2433.863	2	Anxi	203.4722	16
Huli	2111.141	3	Luojiang	125.2894	17
Licheng	1404.353	4	Quangang	79.09763	18
Haicang	1209.668	5	Changtai	78.53895	19
Jimei	1013.2	6	Zhangpu	72.97904	20
Nan'an	668.8897	7	Yongchun	49.45518	21
Shishi	617.5331	8	Nanjing	37.30712	22
Xiangcheng	584.3566	9	Pinghe	29.55761	23
Longhai	579.6245	10	Dehua	17.77763	24
Fengze	564.3684	11	Yunxiao	16.95439	25
Hui'an	404.4446	12	Zhao'an	16.59603	26
Xiang'an	396.4438	13	Dongshan	9.319764	27
Tongan	337.5056	14	Hua'an	4.960915	28

Data source: Calculated by the author.

#### 3.2. Conditional variables

Five conditions are selected in this paper to explore their impact on the intensity of economic linkages:

Urbanization level (CZH) is selected to measure the average value of the urbanization rate of the resident population at the end of the average year from 2011 to 2020.

Infrastructure development (GLLC) is selected to be measured by the share of road mileage in total land area.

Public service level (RJCW) is calculated by selecting the number of beds per capita from the health data of each district and county.

Degree of government intervention (CZZC): The proportion of fiscal expenditures to GDP is selected to measure the degree of local government intervention.

Industrial structure (GYJG): The advanced industrial structure is selected as the measurement variable; that is, the value added of the tertiary industry is used to subtract the value added of the secondary industry.

### 3.3. Calibration

This paper determines the fuzzy set affiliation score based on the existing literature and considering the specific situation of the county economy. In particular, the full affiliation score is 90%, the mediation score is 50%, and the full non-affiliation score is 10%. Table 7 summarizes the post-calibration descriptive statistics of the fuzzy sets for each condition and outcome.

**Table 7** Post-calibration descriptive statistics

Variable	Mean	Standard Deviation	Mini	Max
Economic linkage intensity (YLZ)	0.4285714	0.3528326	0.04	1
Urbanization level (CZH)	0.5039286	0.3509613	0.01	0.95
Infrastructure development (GLLC)	0.4528571	0.3189252	0	0.99
Public service level (RJCW)	0.4939286	0.3064001	0.01	1
Degree of government intervention (CZZC)	0.4875	0.3538222	0.04	0.99
Industrial structure(GYJG)	0.4714286	0.3460875	0.02	1

## 4. Analysis of results

### 4.1. Analysis of necessary conditions

Consistent with previous QCA studies, a necessary conditions analysis is first required. The consistency level responds to the extent to which the cases of the same condition configuration state share the same outcome. This paper limits the threshold value of the necessary conditions to 0.9. Tables 8 and 9 show the results of the necessary conditions analysis for high and low economic linkage intensities, respectively. As seen from the tables, none of the conditions in the knot model has a consistency level greater than 0.9, i.e., none of the conditions are necessary for the outcome variable.

**Table 8** Necessary condition analysis for high economic linkage intensity

	Consistency	Coverage
CZH	0.884167	0.751949
~CZH	0.382500	0.330454
GLLC	0.724167	0.685331
~GLLC	0.591667	0.463446
RJCW	0.623333	0.540853
~RJCW	0.635833	0.538462
CZZC	0.425833	0.374359
~CZZC	0.772500	0.645993
CYJG	0.659167	0.599243
~CYJG	0.560000	0.454054



**Table 9** Necessary condition analysis for low economic linkage intensity

	Consistency	Coverage
CZH	0.418750	0.474841
~CZH	0.781250	0.899928
GLLC	0.486250	0.613565
~GLLC	0.750625	0.783943
RJCW	0.591250	0.684020
~RJCW	0.603125	0.681016
CZZC	0.682500	0.800000
~CZZC	0.466250	0.519860
CYJG	0.495000	0.600000
~CYJG	0.669375	0.723649

## 4.2. Sufficient conditions analysis

Sufficient conditions analysis can demonstrate the possible conditional configurations of multiple factors. Tables 10 and 11 show the results of the sufficient conditions analysis at high and low economic linkage intensities, respectively. According to Ragin (2008), the thresholds for the analysis were set at 0.8 for consistency, 0.5 for PRI, and 0.25 for coverage.

**Table 10** Sufficient conditions configuration for high economic linkage intensity

Conditional variable	High			
	H1	H2	H3	H4
CZH	■	■	■	■
GLLC	■		▪	▪
RJCW	⊗	▪	×	
CZZC		⊗	⊗	⊗
CYJG	⊗	▪		▪
Raw Coverage	0.3725	0.439167	0.3725	0.371667
Unique Coverage	0.0991668	0.144167	0	0.0158333
Consistency	0.862934	0.95471	0.876471	0.864341
Consistency of the overall solution	0.736667			
Coverage of the overall solution	0.865818			

Note: ■ indicates that the core condition is present, ⊗ indicates that the core condition is missing, ▪ indicates that the edge condition is present, × indicates that the edge condition is missing, and a space indicates that the condition is optional.

According to Table 10, the urbanization rate is central to the strength of economic linkages in all configurations. The degree of government intervention has a missing core condition in all three configurations. It shows an irrelevant condition in one configuration, representing that government intervention plays no or a negative role in regional integration. As shown in Table 10, there are four conditional configurations of states

explaining high economic linkage intensity:

(1) H1: CZH \* GLLC ~ RJCW \* ~ GYJG

In H1, the urbanization rate and infrastructure development play a central role; the level of public services and industrial structure is the core condition missing, and the level of government intervention is an irrelevant condition. This configuration represents a path of high economic linkage intensity dependent on the dual drive of economic development level and infrastructure development. At the same time, the industrial structure has not been transformed to an advanced level, and the level of public services is relatively low. Typical cases under this drive are Haicang District and Jinjiang, which are dominated by secondary industries.

(2) H2: CZH \* RJCW ~ CZZC \* GYJG

This configuration indicates that regions will have higher economic linkage intensities driven by the level of urbanization, the level of public services, and the advanced industrial structure. At the same time, the degree of government intervention has an adverse effect on the change of economic linkage intensities under this configuration. Typical cases under this drive are Siming District, Huli District, Xiangcheng District, Fengze District, and Leicheng District, which are all in the main urban areas of Xiamen, Zhangzhou, and Quanzhou, where the infrastructure is already better developed, and thus do not appear in the group state condition. In this configuration condition, the level of urbanization is the core driver of the strength of economic linkages, with the level of public services and industrial advancement as auxiliary drivers.

(3) H3: CZH \* GLLC ~ RJCW \* ~ CZZC

This configuration indicates that the level of urbanization and infrastructure development positively affects changes in the intensity of economic linkages. In contrast, the level of public services and the degree of government intervention have an adverse effect on changes in the intensity of economic linkages. The classic cases of this driver are Jinjiang and Shishi, two county-level cities that mainly focus on manufacturing, so the level of urbanization is the primary driver of the intensity of economic linkages, and the infrastructure is gradually improving, which is a secondary driver. The degree of government intervention is a core condition missing, and the level of public service is a marginal condition missing, which may be due to the more developed private economy in the region and weak policy intervention.

(4) H4: CZH\* GLLC ~ CZZC \* GYJG

This configuration indicates that the level of urbanization, infrastructure development, and industrial sophistication have a positive effect on the change of economic linkage intensity, while the degree of government intervention has a negative effect. This configuration is similar to H2, where less government intervention favours market-driven industrial upgrading. The cases of this group of states are Fengze District, Shishi, Longwen District, and Licheng District.

**Table 11** Sufficient condition group states for low economic linkage intensity

Conditional variable	LOW						
	NH1	NH2	NH3	NH4	NH5	NH6	NH7
CZH		⊗	⊗	▪	⊗	⊗	⊗
GLLC	⊗	⊗	▪				⊗
RJCW				■	■	×	×
CZZC	▪	⊗	×	■	■	×	
CYGJ	⊗		×	⊗	▪	×	⊗
Raw Coverage	0.4175	0.52125	0.275	0.186875	0.288125	0.325625	0.389375
Unique Coverage	0.021875	0.0750001	0.01125	0.00749999	0.02375	0.02375	0.00312501
Consistency	0.915069	0.980023	0.862745	0.917178	0.962422	0.869783	0.956989
Consistency of the overall solution	0.744375						
Coverage of the overall solution	0.892135						

Note: ■ indicates that the core condition is present, ⊗ indicates that the core condition is missing, ▪ indicates that the edge condition is present, × indicates that the edge condition is missing, and a space indicates that the condition is optional.

In order to gain a deeper understanding of the drivers of regional integration, Table 11 demonstrates the group condition for low economic linkage intensity. It can be seen that “happy families are all similar and unfortunate families have their misfortunes”, resulting in more configurations of conditions that lead to weaker economic linkage strength in a particular region. Combining the individual configurations is broadly classified into the following driving paths: urbanization level inhibition (NH3, NH5, NH6), industrial structure inhibition (NH4), infrastructure development-industrial structure inhibition (NH1), urbanization rate-infrastructure development-inhibition of government intervention degree (NH2), urbanization rate-infrastructure development-industrial structure inhibitory (NH7).

Taken together, a low level of urbanization represents a relatively weak economic development of the place, which in turn affects the strength of the place's economic linkage. In the case of the group state NH3 Hua'an, for example, its total GDP is ranked at the back of the pack and is relatively unattractive.

Among these regions, some have a single industrial structure and are dominated mainly by primary or secondary industries, which makes these regions less resistant to external economic shocks, less attractive, and less relevant to the outside world, and thus have a lower strength of economic ties. Typical case for the group NH4 Dehua County, Dehua industry is mainly based on the ceramic industry chain, in recent years, most of the small and medium-sized manufacturers in Dehua actively develop e-commerce, and in the local e-commerce one-stop service chain, but due to the region's internal in the low-end market competition fierce, external competitors Jingdezhen in the high-end market occupies a larger share of the market, compression of the space for enterprise innovation.

From the various driving paths, it can be found that places with weaker infrastructure development have higher trade and people movement costs, and thus are less attractive to other regions. Take the group state NH1, NH2, NH7 all appeared Zhao'an as an example, the reason is that Zhao'an is located in the southernmost part of Zhangzhou, far away from the core area, the infrastructure construction is relatively weak in Xiamen, Zhangzhou

and Quanzhou area, at the same time, adjacent to Guangdong, facing the siphoning effect of the two sides, resulting in more challenging to attract investment and industrial development, and in the combined effect of several factors, the intensity of the economic ties to the surrounding areas is low, and the degree of integration is poor.

## 5. Conclusion

This paper chooses 28 districts and counties in Zhangzhou, Xiamen, and Quanzhou as the research object, uses the method of FsQCA to analyze the group path that leads to the differences in the strength of the economic ties of the districts and counties, and obtains the following conclusions:

First, economic development is the core source of economic linkage intensity, followed by infrastructure development. Higher levels of government intervention may have a negative impact.

Second, from the perspective of regional integration, the level of public services does not dominate, and lower levels do not necessarily lead to a region's lack of attractiveness.

Third, there are regional differences in the choice of industrial structure. For urban core districts, higher quality of public services and industrial sophistication can boost the strength of economic ties. For non-core districts and counties, it is more important to prioritize their own strengths than to promote the transformation of the industrial structure into an advanced one, and the development of primary and secondary industries is instead conducive to enhancing the strength of economic ties.

This paper puts forward the following policy recommendations to promote the economic integration of Xiamen, Zhangzhou and Quanzhou taking into account the new trend and pattern of economic development:

First, the connectivity between non-core counties and core areas should be strengthened to reduce the cost of the flow of factors in the region.

Secondly, it accelerates the convenient sharing of public services to mobilise the construction of economic integration. Xiamen, Zhangzhou, Quanzhou can realise the integration and sharing of cross-city public service resources through the joint construction of intelligent demonstration projects such as intelligent transport and medical care.

Thirdly, it is to build a mechanism for the coordinated development of regional industries, and promote the coordinated development of the economy through the coordinated development of industries, which in turn will promote the development of economic integration. According to the comparative advantages of each district and county's industrial base and factor endowment, a cross-regional communication and collaboration mechanism must be established to form a new rationalization pattern and industrial structure development. For example, Xiamen, Zhangzhou and Quanzhou can promote the integration of the digital economy and the real economy through the construction of digital economy industrial parks to strengthen the training of digital technology personnel, digital empowerment of the countryside, and other ways to promote the development of the digital economy and the integration of the real economy.

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# The Role of Village Regulations in Litigation Source Governance: A Legal and Empirical Analysis Based on Tianjin's 2023 Model Village Regulations

Siying Huo, Yuefeng Wang\*, Ziyuan Xu, Guo Yang

Law Undergraduate, Law School, Tianjin Normal University, Tianjin 300382, China

*\*Author to whom correspondence should be addressed.*

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**Abstract:** This study examines the role of village regulations within China's Litigation Source Governance (LSG) framework, specifically analyzing Tianjin Municipality's 2023 Model Village Regulations. Employing legal analysis and Natural Language Processing (NLP) techniques, the research evaluates the effectiveness, enforceability, and thematic orientation of these regulations in grassroots dispute resolution. Findings reveal a pronounced reliance on moral governance provisions, limited judicial recognition, and significant implementation challenges due to the predominance of non-binding (soft) clauses. The study recommends enhancing judicial recognition through formal confirmation mechanisms, increasing legally binding clauses, and integrating village-level governance more closely with formal judicial processes. This approach not only strengthens local governance but also provides valuable insights for nationwide replication, supporting broader goals of rural stability and governance modernization.

**Keywords:** Village regulations; Litigation source governance; Judicial recognition; Natural language processing; Grassroots governance; Tianjin municipality; Legal enforceability

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## 1. Introduction

### 1.1. Research background and context

In recent years, China has emphasized Litigation Source Governance (LSG) as a fundamental component of its judicial reform <sup>[1]</sup>. LSG aims to prevent disputes from escalating into formal litigation by leveraging grassroots governance mechanisms and non-litigious dispute resolution strategies <sup>[2]</sup>. This approach aligns with China's broader efforts to promote social stability, reduce judicial burdens, and enhance localized governance efficiency <sup>[3]</sup>.

One of the most critical tools in the LSG framework is Village Regulations<sup>[4]</sup>. As customary rules formulated by local rural communities, village regulations serve as a primary mechanism for self-governance, ensuring social cohesion and dispute resolution without resorting to the formal court system<sup>[5-7]</sup>. In many rural areas, village regulations function as an informal yet influential system of governance, complementing statutory law and providing a basis for alternative dispute resolution (ADR)<sup>[8, 9]</sup>.

Against this backdrop, Tianjin Municipality has taken significant steps in advancing grassroots governance by evaluating and selecting a group of “Model Village Regulations” in 2023. These regulations reflect the latest innovations in integrating village governance with litigation source governance, offering valuable insights into how customary norms can be effectively institutionalized within China’s legal framework<sup>[10]</sup>.

However, this development raises several critical questions: “How does Tianjin’s grassroots governance model influence the formulation, implementation, and enforcement of village regulations?”; “To what extent do these regulations contribute to dispute prevention, mediation, and legal alignment within the LSG framework?”

## 1.2. Research questions and objectives

This study aims to address four key research questions:

- (1) What role do Tianjin’s 2023 Model Village Regulations play in the litigation source governance system?
- (2) How do these regulations function in dispute prevention, mediation, and legal integration?
- (3) What is the legal validity of these village regulations? Do they encounter conflicts with national law or suffer from weak enforceability?
- (4) Can an empirical analysis of these regulations, using legal review and textual data mining, reveal more effective optimization strategies?

To answer these questions, this research will conduct:

- (1) A legal analysis of village regulations within the LSG framework, assessing their compatibility with China’s statutory laws.
- (2) An empirical investigation using Natural Language Processing (NLP) and legal text analysis to extract governance patterns from Tianjin’s Model Village Regulations.
- (3) A policy evaluation to explore how village regulations can be better integrated into China’s formal legal system.

## 1.3. Research significance

This study offers three key contributions:

- (1) Theoretical contribution

By applying Legal Pluralism Theory, this research examines the legal status of village regulations and their interactions with formal legal institutions. This study expands on existing discussions on grassroots governance and alternative dispute resolution (ADR) in China’s legal framework.

- (2) Practical value

This study provides empirical insights into Tianjin’s 2023 Model Village Regulations, highlighting how they function in LSG, mediation, and legal harmonization. The findings contribute to the broader understanding of village regulations as governance tools, particularly in preventing disputes before litigation.

### (3) Policy impact

This research offers recommendations for future legislation on village regulations, emphasizing judicial confirmation mechanisms and legal standardization. It informs policymakers on how to optimize grassroots governance structures to ensure village regulations play a more formalized role in LSG.

## **2. Theoretical framework**

### **2.1. Legal pluralism and the legal status of village regulations**

#### **2.1.1. Concept of legal pluralism**

Legal pluralism refers to the coexistence of multiple legal systems within a single social or political entity. It recognizes that in addition to state law, customary norms, religious laws, and informal dispute resolution mechanisms can function as de facto legal orders within specific communities. Scholars such as Griffiths (1986) and Merry (1988) argue that legal pluralism is particularly prevalent in societies with strong local traditions and limited state enforcement capacities.

In China, legal pluralism manifests through the interaction between statutory law and localized governance practices, including village regulations. While the national legal system provides a formal, centralized framework, many rural communities rely on customary rules to maintain order and resolve disputes. This parallel legal system creates both opportunities and challenges in integrating grassroots governance mechanisms into the formal legal framework.

#### **2.1.2. Legal ambiguities in the status of village regulations**

Village regulations occupy a semi-formal legal space in China's governance structure. On the one hand, the Organic Law of the Villagers' Committees of the People's Republic of China (1998) allows villages to formulate their own regulations, provided that they do not contradict national laws or infringe upon citizens' rights. On the other hand, the lack of explicit legal recognition in judicial proceedings makes their enforceability uncertain.

Key legal questions surrounding village regulations include:

##### (1) Are village regulations legally binding?

While they serve as governance tools, they lack direct statutory authority and are often treated as informal norms rather than enforceable rules.

##### (2) How do courts handle disputes involving village regulations?

In some cases, courts reference village regulations as evidence of customary practices, but they do not grant them independent legal force.

##### (3) To what extent do village regulations conflict with national law?

Some village regulations impose fines, sanctions, or restrictions beyond their legally permitted scope, leading to potential legal disputes.

Thus, while village regulations contribute to local governance, their uncertain legal standing limits their effectiveness in formal dispute resolution processes.

## **2.2. Village regulations in the three-governance model**

China's Three-Governance Model integrates three key dimensions of governance in rural areas:

(1) Self-governance: Emphasizing community-based rule-making and participatory governance.

(2) Rule of law: Ensuring that governance practices comply with national laws and legal standards.

(3) Moral governance: Promoting ethical values and social harmony through cultural traditions.

Village regulations are a central element of this model, balancing local autonomy, legal compliance, and ethical principles. However, in practice, challenges arise in maintaining equilibrium among these three components:

- (1) Over-reliance on moral governance: Many village regulations focus on moral persuasion rather than legal enforcement, making compliance voluntary rather than mandatory.
- (2) Weak rule of law integration: Some regulations include punitive measures that lack legal authorization, leading to potential legal disputes.
- (3) Limited autonomy in practice: While village self-governance is encouraged, higher-level administrative authorities often intervene, reducing local regulatory independence.

This research examines how Tianjin's 2023 Model Village Regulations navigate these challenges, particularly in ensuring a more effective balance among autonomy, legal enforcement, and social norms.

### **3. Methodology**

#### **3.1. Data collection**

To analyze the role of village regulations in litigation source governance, this study employs a mixed-methods approach that combines legal analysis and empirical data mining. The research is based on Tianjin's 2023 Model Village Regulations, a set of selected village regulations recognized by the local government for their effectiveness in grassroots governance and dispute resolution.

##### **3.1.1. Selection of sample village regulations**

The dataset consists of village regulations officially published or recognized by Tianjin's municipal government in 2023. The criteria for selection includes: (1) The regulations must be explicitly linked to dispute resolution or conflict prevention; (2) They must demonstrate legal compliance or include legal references to national or local laws; (3) The sample includes a diverse range of village sizes, economic conditions, and governance models to ensure representativeness.

##### **3.1.2. Supplementary legal and judicial data**

To assess the legal standing of village regulations, additional data sources include:

- (1) Judicial cases: Court rulings that reference village regulations as part of dispute resolution.
- (2) Policy documents: Guidelines issued by municipal and national authorities on litigation source governance and grassroots legal reforms.
- (3) Interviews and reports: Insights from local governance officials and legal experts on the challenges and best practices in integrating village regulations into the formal legal system.

#### **3.2. Empirical approach: NLP-based text analysis**

To systematically evaluate how village regulations address dispute resolution, this study utilizes Natural Language Processing (NLP) techniques for text mining and semantic analysis. This method allows for quantitative insights into how village regulations incorporate elements of litigation source governance, legal compliance, and mediation mechanisms.

### 3.2.1. Key analytical metrics

The textual analysis is structured around the following key metrics:

- (1) Keyword frequency analysis: Identifies the most common legal and governance-related terms, such as “mediation”, “litigation”, “legal aid”, and “sanctions”.
- (2) Governance model classification: Categorizes provisions under the Three-Governance Model to assess whether village regulations emphasize self-governance, rule of law, or moral governance.
- (3) Regulatory strength assessment: Differentiates between hard regulations—which impose enforceable obligations—and soft regulations—which rely on moral persuasion or voluntary compliance.

### 3.2.2. Application of NLP tools

- (1) Text segmentation and tokenization: Processes village regulations to extract meaningful text units.
- (2) Part-of-speech tagging and named entity recognition (NER): Identifies legal references and governance-specific terminology.
- (3) Sentiment and compliance scoring: Assesses the tone of enforcement and whether regulations align with legal principles.

## 3.3. Legal analysis

In addition to empirical analysis, this study conducts a doctrinal legal analysis to examine the compatibility of village regulations with China’s statutory laws. The analysis focuses on three key areas: first, it identifies legal conflicts by uncovering contradictions between village regulations and higher-level national laws such as the Civil Code and the Administrative Law; second, it reviews judicial precedents to analyze how courts have either upheld or invalidated village regulations in practice; and third, it explores legal reform proposals aimed at improving the enforceability and legitimacy of village regulations within China’s formal legal system.

## 4. Findings and discussion

### 4.1. The legal effectiveness of Tianjin’s Model Village Regulations

This study examines the legal effectiveness of Tianjin’s Model Village Regulations in terms of their judicial recognition and enforceability. Firstly, analysis of judicial practice reveals limited judicial acknowledgment of village regulations as legally binding norms. Most provisions within these regulations function as informal or supplementary guidelines rather than legally enforceable rules. The provisions explicitly recognized by judicial authorities typically involve issues directly linked to public order and community safety, such as prohibitions on damaging public property or endangering communal safety. Conversely, provisions based on ethical or moral persuasion, such as promoting family values or traditional customs, often lack formal recognition, highlighting the nuanced distinction between normative influence and enforceable legality.

Among specific provisions, the most legally binding clauses are those utilizing rigid language, including terms such as “must,” “prohibit,” and “severely forbidden.” Examples include prohibitions against damaging public facilities or engaging in behaviors detrimental to public safety. However, clauses advocating moral behavior or community volunteering, characterized by language such as “encourage” or “recommend,” are frequently contested due to their non-binding nature and absence of enforceable sanctions.



## 4.2. NLP analysis results

The NLP analysis of Tianjin's 2023 exemplary village regulations offers quantitative insights into their thematic emphasis and structural distribution across three governance dimensions: legal governance, autonomous governance, and moral governance.

Keyword analysis, employing TF-IDF algorithms, highlights a pronounced focus on dispute prevention and mediation within these regulations. The terms “mediation” and “dispute” emerged as the most frequently mentioned keywords, indicating village regulations' priority in addressing conflicts at an early stage through non-litigious means. Conversely, formal judicial mechanisms such as “litigation” and “arbitration” were notably absent, underscoring a reliance on informal dispute resolution mechanisms embedded in village-level governance structures.

Categorization of provisions into legal governance, autonomous governance, and moral governance reveals substantial variation: moral governance dominates significantly (180 occurrences), followed by legal governance (36 occurrences), with autonomous governance showing the least emphasis (15 occurrences). This distribution quantitatively demonstrates that current village regulations are predominantly moral-oriented, leveraging traditional values and customs rather than legal sanctions or autonomous community mechanisms.

## 4.3. Challenges in implementing village regulations

Implementation challenges identified in this study reflect two critical areas: practical enforcement limitations and potential legal conflicts. Firstly, despite the normative intentions of village regulations, their practical enforceability remains limited due to a predominant reliance on “soft” or morally driven provisions. Approximately 64.15% of analyzed clauses fall into the “soft” category, characterized by terms like “encourage” and “advocate.” In contrast, only 35.85% constitute “rigid” clauses with explicit prohibitions or mandatory requirements. This structural imbalance undermines the ability of village regulations to impose enforceable obligations, weakening their role in pre-litigation governance.

Moreover, certain village regulations exhibit potential conflicts with national laws, particularly where provisions encroach upon state-sanctioned legal jurisdictions or conflict directly with established statutory norms. The absence of explicit provisions regarding formal legal mechanisms such as litigation or arbitration further exacerbates these legal conflicts, reflecting a systemic disconnect between informal village governance structures and formal state legal frameworks.

## 4.4. Challenges in implementing village regulations

The implementation of village regulations faces notable challenges, primarily stemming from their structural reliance on moral persuasion rather than enforceable legal instruments. Enhancing practical binding force thus necessitates rebalancing the regulatory framework by increasing the proportion of rigidly enforceable clauses, clearly anchored in statutory legitimacy.

Additionally, resolving legal conflicts between village regulations and national laws requires establishing clearer connections and delineations between village-level norms and formal legal procedures. Strengthening the role of autonomous governance by encouraging broader democratic participation in drafting, enacting, and enforcing village regulations could also enhance their legitimacy and effectiveness. Ultimately, these measures aim to transition village regulations from predominantly ethical guidelines into robust, legally cognizable instruments capable of effectively addressing disputes at their source.

## 5. Policy implications

### 5.1. Policy recommendations

To enhance the legal status and enforcement mechanisms of Tianjin's village regulations, the following policy recommendations are proposed:

Firstly, it is essential to strengthen the legal standing of village regulations through explicit judicial recognition <sup>[11]</sup>. Introducing a judicial confirmation mechanism can significantly enhance their enforceability, ensuring that agreements reached through village-level mediation are legally binding when confirmed by courts <sup>[12]</sup>. Specifically, village regulations should clearly delineate the process for dispute identification, reporting, mediation, and feedback, aligning closely with Tianjin's existing integrated mediation system comprising People's Mediation Committees, administrative mediation bodies, and judicial mediation frameworks.

Secondly, establishing a systematic collaboration involving village legal advisors, judicial offices, and People's Mediation Committees is crucial <sup>[13]</sup>. Village regulations should incorporate clear provisions requiring legal advisors' participation during both the drafting stage and mediation procedures, particularly for disputes involving property rights, contracts, and familial matters. This integration can help mitigate procedural errors and strengthen legal compliance, ensuring that mediated outcomes adhere strictly to national legal standards <sup>[14]</sup>.

Lastly, implementing a rigorous legal review and filing mechanism is recommended <sup>[15]</sup>. Judicial administrative departments, in cooperation with courts and legal advisors, should regularly review village regulations to ensure consistency with national laws and regulations. Regular revisions, ideally every three years, should also be mandated to ensure continued legal relevance and effectiveness.

## 6. Conclusion

The analysis indicates that while Tianjin's Model Village Regulations exhibit promising features for wider national implementation, several critical areas require enhancement for broader applicability. Tianjin's approach, emphasizing moral governance supported by local customs and ethical norms, significantly contributes to grassroots dispute prevention. However, the heavy reliance on "soft" provisions undermines their enforceability and limits their effectiveness in the formal judicial context.

For Tianjin's village regulations to become a scalable national model, further refinement is necessary. Enhancing the balance between enforceable legal provisions and moral guidelines is crucial. Additionally, strengthening the role of autonomous governance mechanisms through greater democratic participation and clearer legal delineations can significantly bolster their practical impact.

In conclusion, advancing the rule-of-law framework within village regulations necessitates deeper integration with formal judicial processes, enhanced legal education among villagers, and systematic involvement of legal advisors throughout the regulatory lifecycle. Implementing these measures will ensure village regulations effectively support grassroots governance, promoting sustainable rural stability and development.

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# A Research Review of International Carbon Tax and the Comparative Analysis of International Carbon Tax Schemes

Yuxue Li\*

Nanjing University of Science and Technology Zijin College, Nanjing 210023, Jiangsu, China

*\*Author to whom correspondence should be addressed.*

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**Abstract.** International carbon tax issues such as carbon leakage and carbon neutralization have become major topics of social concern. Based on the practical experience of carbon tax system in individual countries, this paper integrates the existing research of international carbon tax scholars to the classification and comparative analysis of international carbon tax schemes. Using a literature review approach, this dissertation mainly applies the method of qualitative analysis to explain and compare the contents of four international carbon tax options. Through the analysis and evaluation of individual countries' carbon tax practice, the two-country model is verified. Through the method of comparative analysis, the schemes are evaluated from four dimensions and an assessment is made. The difference of carbon tax among countries makes the internal policies of countries adjust accordingly with the changes of international environment, which promotes the gradual convergence of carbon tax schemes. The results intend to provide reference to further study the issue on international carbon tax.

**Keywords:** Carbon tax; International carbon tax schemes; Border-tax adjustment

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## 1. Introduction

According to the emission information provided by U.S. Environmental Protection Agency, carbon dioxide accounts for about 81% of greenhouse gases while methane and nitrous oxide only account for 10% and 7% of the total emissions respectively <sup>[1]</sup>. Since the United Nations Framework Convention on Climate Change (UNFCCC) came into effect, international attention to carbon emissions, especially carbon emissions trading and relevant schemes, has been increasing. Based on Sandmo's two-country model, this paper will study the different arrangement of carbon tax mechanism on different countries and focus on the interaction between countries. Potential factors which lead to the success or failure of carbon tax will also be inferred <sup>[2]</sup>.

According to the simplified two-country model, countries in the world are roughly divided into developed



(relatively rich) countries and developing (relatively poor) countries, which raises the issue of policy interaction. Each individual country is affected by the environmental pollution of all other countries. Following the international carbon tax schemes fall into four categories, namely, uniform international taxes, non-uniform international taxes, harmonized domestic taxes, and domestic taxes & border-tax adjustment. This paper aims to explore the rationality and development prospects of carbon tax system.

## 2. International carbon tax schemes

### 2.1. Background

OECD designed several models of greenhouse gas emission tax system in its publication “International economic instruments and climate change”, which can be divided into two models: financing and stimulation according to tax purposes. Meanwhile, based on the level of international integration, the carbon taxes of the above two modes are divided into six types as shown in **Table 1**.

**Table 1.** Tax system model of greenhouse gas emission tax

Purpose	Unilateral national tax	Unilateral national tax	Unilateral national tax
Financing	I	II	III
Stimulation	IV	V	VI

Unilateral national tax means that a few countries levy carbon tax at the national level for the purpose of carbon emission reduction. However, in order to improve international competitiveness, some countries often set up a large number of preferential policies or even tax-free measures for energy intensive industries, which seriously restricts the favorable impact of carbon tax system on the environment and aggravates the imbalance of carbon tax burden between countries. This kind of tax system can be seen as a transitional stage to a tax system with high international consistency. The coordinated national tax is an extension of unilateral national tax, trying to coordinate the emission reduction measures of a single country with the carbon tax policies of various countries. International tax is a tax paid by each member state to international organizations. However, OECD also recognizes that such a scheme is almost impossible to achieve in the current international environment, and there is a high possibility of not implementing and evading the agreement.

### 2.2. Scheme 1: Uniform international taxes

The global unified international carbon tax was first proposed by Hoel <sup>[3]</sup>. He stated that in solving the problem of global warming, setting the same reduction target for each country under a certain target will surely lead to low efficiency, because this method does not take into account the cost differences of different countries to carry out the reduction plan. On the contrary, the use of tax may be an effective way, and this tax is the international carbon tax. He also stressed that the carbon tax can only be effective if a unified standard is implemented on a global scale, but it seems difficult to achieve. This difficulty is reflected in two aspects: one is that if carbon tax is managed internationally and collected by a central institution, it may involve political issues such as national sovereignty; the other is that if carbon tax is collected by different countries themselves, it will lead to free riding problem. Therefore, the carbon tax should be collected by a jointly recognized central organization, such as the United Nations Environment Program.

Specific collection agencies and relevant supporting agencies should be set up. It is suggested that the carbon tax base should be the carbon dioxide emission, or the carbon dioxide reduction promised by each country; tax rates are consistent for each country; The carbon tax should be returned to countries in some way. The specific operation method is that at the end of each collection cycle (1 year or 3–5 years), the selected international central institution will debit the international carbon tax that a country should pay according to the carbon dioxide emissions of each country, and credit the return that the country should receive from the total tax revenue after deducting the management costs of international institutions. Therefore, the net tax paid by each country to the international carbon tax collection agency in each period is the difference between the tax payable and the return. This net tax may be positive or negative. When the management cost is ignored, the sum of the net taxes of the participating countries should be zero. Although it may be utopian to adopt rules based on unified background needs and managed by unified international tax authorities, the aim of this idealized scheme is to stimulate the discussion of resource sharing and international communication under the tone of increasing globalization.

The features are: (1) Carbon tax is levied on each country according to its emissions based on a unified tax rate, and (2) The tax revenue should be collected by independent international organizations and distributed according to the agreed rules.

### **2.3. Scheme 2: Non-uniform international taxes**

The non-uniform international carbon tax scheme is very similar to the unified international carbon tax in terms of collection method, both of which advocate the unified collection and return of tax revenue through universally recognized international institutions. The main difference is that the former does not insist on the uniform tax rate for all countries, on the contrary, it advocates the differential tax rate. This kind of international carbon tax scheme was first proposed by Murty, which advocated the method of fiscal federalism, in which the domestic carbon tax was collected by each country, and the international carbon tax was collected and managed by international agencies, and the tax was returned according to the atmospheric conditions of each country <sup>[4]</sup>. In this way, the international carbon tax rate of each country will depend on its own carbon dioxide emissions, profit tax imposed on producers, production of carbon intensive products and other relevant variables.

To solve the problem of tax return, Gersbach designed a special international carbon tax operation scheme, the Global Refunding System (GRS) <sup>[5]</sup>. In the global return system, at first, the largest 20 developed countries injected start-up funds to form a global fund, and other countries decide whether to join or not. Countries can become GRS members as long as they accept the GRS regulations and pay the lowest level of carbon tax. Each member state sets its own carbon tax rate and submits the carbon tax revenue of each period to the global fund. The GRS allocates the Global Fund in proportion to each member country's share of the previous period's carbon dioxide emission reduction in the total emission reduction of all member countries. This kind of return may only use part of the tax revenue for return at the initial stage. When the fund amount accumulates to a certain extent and remains stable, the amount of return is equal to the total tax revenue plus the interest income of the fund. Member states are free to join or withdraw during the expropriation period. The return system of this model is set up according to the rules beneficial to developing countries, but once the country exits, it will lose the current refund.

Hoel, who supports the unified carbon tax policy, opposes the non-uniform carbon tax based on national background <sup>[4]</sup>. He focuses on criticizing its inefficiency and believes that the workload of determining differential tax rates and tax return according to specific national conditions is huge. In addition, there is uncertainty about whether countries' own emission monitoring is in place and whether there is concealment. Supervision also requi-

res a lot of human and material resources, which is almost impossible to achieve.

The features are: (1) There are non-uniform international carbon taxes in the world. The differences are reflected in the different tax rates imposed on different countries, and there is no clear requirement to take carbon dioxide emissions as a unified tax base, and (2) Specific institutions and systems are needed to implement the unified tax collection and realize the reasonable distribution and return of tax revenue.

## **2.4. Scheme 3: Harmonized domestic taxes**

Since the Kyoto Protocol, some scholars advocate a unified carbon tax. A unified global carbon tax seems to achieve the emission reduction target more effectively, and it is also convenient for international coordination and management. What they advocate is to ask countries to achieve a unified domestic carbon tax by reaching an agreement.

Nordhaus confirmed the necessity of consistency of carbon tax in different countries and industries from the theoretical level, but this consistency may not be achieved in the implementation. Thus, his research aims to indicate that the ideal scheme should be taken as the guidance in the design of the system<sup>[6]</sup>. In the study of global warming, Stiglitz discusses two issues: one is that developed countries such as the United States refuse to accept and participate in carbon emission reduction plans; the other is that developing countries question the allocation of emission reduction targets, that is, why developed countries that previously emitted more carbon dioxide now have more emission targets than developing countries. In order to coordinate these international issues, everyone should be required to pay taxes equivalent to the social cost of carbon emissions, which can solve most of the distributional debate<sup>[7]</sup>. In addition, the tax design should be adjusted according to the development of technology and global warming, which means that the unified tax rate is not unchangeable and needs follow-up study and response according to the actual situation. As for tax revenue, Stiglitz believes that special funds can be established by agreement to invest in global public utilities, but it is more realistic for countries to keep and use tax revenue themselves, to avoid potential injustice and distribution disputes<sup>[7]</sup>.

Aldy and Stavins support a unified domestic tax rather than an international carbon tax levied by specialized agencies, believing that the former is more acceptable to most of the countries<sup>[8]</sup>. Each country can reach an agreement on domestic carbon tax, levy a unified carbon tax rate and dispose of the carbon tax revenue separately. Since the uniform carbon tax rate is inherently unfair, it needs international transfer payment; the developed countries transfer to the developing countries according to the principle of agreement or the developed countries use the carbon tax revenue to finance the research of zero carbon technology projects and other carbon emission reduction projects of the developing countries. In the face of the lack of fairness brought about by the unified tax rate, they proposed to levy carbon tax only on countries with a certain income level in the short term and exempt those countries with lower income level and less historical emissions. This is equivalent to dividing international countries into two batches, one is similar to developed countries, the other is similar to developing countries, which is consistent with Sandmo's two-country model<sup>[9]</sup>. As the developed countries generally emit more than the developing countries, they should undertake more emission reduction obligations. Through the unilateral payment of developed countries to developing countries, the equity of global carbon emission reduction obligations can be maintained. However, Stiglitz also stressed the potential risk of aggravating the opposition of some developed countries under this transfer payment policy<sup>[7]</sup>.

The features are: (1) All countries reach an international agreement on domestic carbon tax, and the tax rate is required to be consistent in theory, but the implementation can be adjusted according to the situation, and (2)

Countries collect and dispose the income by themselves rather than by special international organization.

## 2.5. Scheme 4: Domestic taxes & border tax adjustment

Considering that unilateral carbon tax in developed countries will reduce the international market competitiveness of their domestic industries and lead to carbon leakage, many scholars believe that border-tax adjustment can be regarded as an effective means to protect the competitiveness of domestic industries and prevent carbon leakage. The border-tax adjustment discussed in this dissertation refers to the principle of maintaining tax neutrality by taxing the imported products without carbon tax so that the tax rate and price of the imported products are equivalent to those of the same products with carbon tax. This combination of domestic carbon tax and regulatory tax achieves carbon emission reduction targets and safeguards domestic interests.

The original intention was to hope that EU countries could impose import tax on goods that did not comply with the Kyoto protocol. Otherwise, after the EU carbon emission trading mechanism began to operate, the goods produced by EU countries would encounter unfair competition, especially in high energy consuming industries. Some studies suggest that the border regulation tax system can be used to reduce the impact on the competitiveness of the country<sup>[10,11]</sup>. In practice, the report of Sweden's national trade agency proposes three ways to collect the border regulation tax. One is to levy adjustment tax according to the carbon emission of imported products in the production process, which requires the imported products to provide the necessary emission certificate. Second, the importing country sets up a unified standard border regulation tax according to the product category and does not need to hold a carbon emission certificate. The third is to integrate the first two methods. The importing country sets emission standards for each product and sets adjustment tax. If the carbon emission of imported products is lower than the standards set by the importing country, the tax can be reduced.

Mattoo *et al.* also proposed that industrial countries that implement carbon emission reduction impose additional border taxes on imports from countries with lower carbon prices, namely carbon-tax adjustment<sup>[12]</sup>. The adjustment of border tax based on the carbon content of domestic production will effectively solve the competitiveness of producers in high-income countries and reduce the adverse impact on the trade of developing countries. In addition, aiming at the problem of carbon leakage, through the general equilibrium model, it is predicted that in the 14 years since 2000, the imposition of import carbon tariffs on non-OECD countries to OECD countries will probably reduce the carbon leakage by as much as 80%<sup>[13]</sup>. In March 2021, the European Parliament passed a resolution on the EU carbon border regulation mechanism (CBAM) compatible with the WTO. The proposal claims that if some countries that trade with the EU fail to comply with carbon emission regulations, the EU will impose carbon tariffs on their imports. The logic of imposing a carbon-tax adjustment seems to be very simple, that is, without it, the EU may reduce emissions by transferring polluting production, which will harm global climate benefits. On the one hand, the additional tax can ensure the tax on high carbon products in order to promote industrial transformation; on the other hand, it can protect European manufacturers from the impact of products from countries with lower environmental standards.

The features are: (1) Some countries implement carbon tax, and impose border-tax adjustment on imports from countries that do not implement carbon tax, and (2) There is no independent international body to manage the carbon tax, no international distribution of tax revenue and international transfer payment.

## 2.6. Summary

In this chapter, four mainstream international carbon tax proposals are summarized, and their respective



characteristics are briefly concluded. The specific comparison of their characteristics is shown in the **Table 2** below.

**Table 2.** Characteristics comparison of four schemes

Features	Scheme 1	Scheme 2	Scheme 3	Scheme 4
Unified tax rate?	R	Q	R (Adjusted)	Q
Tax refund?	R	R	R	Q
Transfer payment?	Q	Q	R	Q
Independent international organizations?	R	R	Q	Q
Border adjustment?	Q	Q	Q	R

### 3. Comparative analysis of four options

#### 3.1. Cost effectiveness

Cost-effective analysis is a method to evaluate the value of a project by comparing the total cost and benefit of the project. The realization of cost-effectiveness requires the maximization of benefit under the same cost condition or the minimization of cost under the same benefit condition <sup>[14]</sup>. Applying the principle to implementation of international carbon tax, the marginal cost of emission reduction in various countries should be basically consistent.

Uniform International Taxes advocate taking a country's total carbon emissions as the collection object, and the collected carbon tax should be returned to all countries according to the pre-agreed refund ratio. Since the income returned is determined in advance, the amount of refund changes little with the change of tax paid, which is almost negligible. Therefore, in order to maximize income, many countries tend to make the cost of carbon dioxide emission reduction equal to the international carbon tax rate, which means that a high-intensity carbon tax policy is not necessarily the best choice. If a country's emission reduction cost is greater than the international carbon tax, it can choose to reduce emissions reduction to increase revenue. If it is less, the country can choose to increase the intensity of emission reduction to increase emission reduction, so as ensure the stability of income. Therefore, the marginal cost of carbon dioxide emission reduction will always be consistent with the international carbon tax, and the maximum income of the country will be most likely to be achieved. Therefore, under the international carbon tax background of implementing the uniform carbon tax rate in Scheme 1, the marginal emission reduction cost of all countries will be basically consistent with the international carbon tax, and the fluctuation range will not be too large, which can be considered as the realization of cost-effectiveness.

In Scheme 2, non-uniform international carbon taxes, the carbon tax rates of different countries are different, and there is no clear unified tax base based on carbon dioxide emissions. Therefore, cost-effectiveness is hard to achieve.

Although Scheme 3 theoretically requires the unification of domestic taxes by reaching international agreements, it does not require complete unification. There is still room for it to adjust according to its own situation. This means that tax rates are likely to be different across countries. Secondly, each country's tax system is different, even if the same tax rate is guaranteed, the actual cost of carbon tax to the country may be different. In addition, given that the country itself can offset the carbon tax effect by reducing other direct or indirect taxes and increasing additional subsidies, it is almost impossible for countries to unify the actual carbon tax burden.



Many variables will affect the consistency of cost, so the theoretical cost-effectiveness of this scheme may not be realized.

Scheme 4 supports the implementation of carbon tax by some countries and border-tax adjustment on imports. This method maintains the balance of domestic carbon emission reduction cost; the domestic market realizes the unification of domestic and imported goods emission reduction cost, so as to ensure that domestic goods and imported goods without carbon tax have the same competitiveness. However, this option does not try to solve the problem of cost consistency of international emission reduction. Therefore, it does not achieve cost-effectiveness in the international context.

In conclusion, in terms of cost-effectiveness, Scheme 1 may be the best, Scheme 4 is likely to be the worst in the international level, and Scheme 3 is slightly better than or equal to Scheme 2.

### 3.2. Fairness

Aldy and Stavins advocated fairness in international emission reduction cooperation, which means that relatively rich countries should first undertake emission reduction obligations, implement carbon tax and other emission reduction measures, and bear more emission reduction costs than relatively poor countries<sup>[8]</sup>. Carbon dioxide emission is not only a global issue, but also a historical issue. Due to decades of development in developed countries, infrastructure construction and production based on fossil fuels will inevitably lead to carbon emissions of relatively rich countries far greater than those of less developed countries and regions. Therefore, considering the different historical responsibilities of developed and developing countries, the implementation of international carbon tax pays more attention to fairness and adhere to the principle of “common but differentiated”.

Scheme 1 treats all countries equally, but it does not mean that it is completely fair. The proportion of tax refund is also a factor affecting fairness. When the tax rate is fixed, if the tax refund ratio can correctly reflect the historical responsibility of developed and developing countries, then fairness can be achieved. Otherwise, the disharmony between refund ratio and responsibility will destroy fairness, which is likely to benefit the developed countries and damage the interests of the developing countries<sup>[9]</sup>. Thus, the fairness of the scheme depends on the balance between refund and responsibility.

Scheme 2 implements different carbon tax rates for different countries according to certain conditions and returns tax revenue according to regulations. The fairness of the scheme is reflected in the consideration of the differences in economic conditions. However, it is uncertain, because it cannot truly reflect the social and historical responsibility.

Scheme 3 requires all countries to implement a unified domestic carbon tax, and international agreements need to attach the rules of transfer payment or other assistance from developed countries to developing countries. This kind of transfer payment reflects the principle of fairness to a certain extent. Fairness can be realized as long as the transfer payment system can correctly handle and solve the problem of the difference of historical responsibility between developed and developing countries.

Scheme 4 assumes that developed countries bear most of the carbon tax costs and their emission reduction burden is heavy because they have priority over other countries in implementing and paying carbon taxes. In order to reduce the pressure of international commodity price competition, the products exported from developing countries to developed countries need to bear part of the tax burden. From the perspective of developed countries, this is conducive to the economic interests of the importing countries and seems to be more conducive to the maintenance of fairness. However, the situation in developing countries will not be optimistic. On the surface,

only products exported to developed countries by developing countries will bear this share of the tax. In fact, developing countries not only undertake the obligation of emission reduction, but also have the problem of net tax loss. Because there is no uniform tax refund system and transfer payment system in the world, developing countries cannot obtain tax return and transfer payment after they pay these taxes to export destination country, which will result in irreparable economic losses. Besides, due to the increase of export costs and the decline of price competitiveness, the export industry of developing countries will suffer a huge blow. Taking China as an example, Mattoo et al. confirmed the negative impact of such a scheme on the trading partners who are subject to the border regulation tax <sup>[12]</sup>. The export volume of China's manufacturing industry will drop to four-fifths of its original value. The export volume of low and middle-income countries will drop by 15%, and their income will correspondingly drop by 2.5%. In addition to the impact on the economy and trade, whether the border regulation policy is in line with the international trade law is also worrying, and the important factor to be considered is fairness.

Based on the analysis, the fairness of the first three depends on the system design (tax return system & transfer payment system). Theoretically, if the system design can be implemented and play a role, the three schemes will achieve fairness. In comparison, Scheme 4 seems rather unfair. This kind of carbon tax on imported products will evolve into a green trade barrier, which is not conducive to the free circulation of global goods and the development of international trade.

### 3.3. Participation

The extent of participation is based on the idea that the more countries participate in and the more perfect the relevant supporting institutional arrangements, the higher the degree of participation. Ensuring extensive participation will effectively promote the coordination of global emission reduction measures and reduce the risk of carbon leakage (energy intensive industries are transferred from emission reduction countries to non-emission reduction countries). The scope of participation is embodied in two aspects: before and after the agreement.

Before the agreement, the number of participating countries is the determinant of participation. Considering that all four schemes are in the stage of conceptual design, it is impossible to compare the actual number of participating countries in the implementation. This paper regards incentive measures as an agent to help judge participation to consider the design of incentive mechanism that affects participation instead of the number of participating countries for comparative analysis. Scheme 1 and Scheme 3 basically require all countries to participate in the design of carbon tax system. Regrettably, some countries refuse to recognize climate change and bear corresponding responsibilities and obligations, and international consultations have great uncertainty. Scheme 2 is implemented by developed countries first and supplemented by developing countries later. Due to the historical responsibility of developed countries for emission reduction, carbon emission reduction is a matter for developed countries and the driving force for emission reduction is relatively large. Since then, the participation of developing countries in carbon emission reduction has been basically icing on the cake with advantages outweighing disadvantages. Therefore, the incentive effect of the scheme will be better than that of Scheme 1 and Scheme 3, and the corresponding degree of participation will also be higher than the two schemes. The border-tax adjustment of Scheme 4 is mainly aimed at the internal protection tax of developed countries, which is only applicable to some relatively rich countries. Carbon tariff of the USA is a typical example of achieving this goal. Therefore, only some countries will participate and form an informal alliance, so it could not achieve extensive participation.

After the agreement, participation is mainly reflected in the compliance after the implementation of the policy. Institutional supervision and breach clause are the most effective ways to ensure compliance. Thus, the analysis will consider the supervision and management of the implementation of the participating countries in the program design and the punishment for violation of international agreements. The system design of Scheme 1 and Scheme 3 does not involve the specific content of breach of contract while Scheme 2 gives certain punishment to the withdrawal behavior of the participating countries, that is, the person who withdraws from the agreement will lose the current tax refund. Scheme 4 is only implemented within some countries, and there is no international uniform agreement, so it does not involve breach of contract.

In general, under the known system design conditions, the participation of Scheme 2 is likely to be more extensive than other schemes.

### 3.4. Operability

Operability usually refers to the feasibility or difficulty of the operation of the scheme.

Scheme 1 requires all countries to reach an agreement on the tax rate, and it is necessary to choose an independent organization to manage and distribute the tax revenue. In view of the current international situation, most individual countries are dominated by their own interests, and the unified tax rate is bound to damage the interests of some countries. Therefore, it is difficult to reach a consensus and maneuverability is weak.

Similar to Scheme 1, Scheme 2 also needs special international institutions and international carbon tax system, but it does not need to reach a unified tax rate, so negotiation might succeed in the initial stage.

Scheme 3 does not need a unified independent agency to manage tax collection and distribution, but it is still difficult to achieve a unified carbon tax agreement in the short term. Moreover, the formulation and implementation of transfer payment system from developed countries to developing countries will also face obstacles. Taking Germany as an example, Li and Du showed that the transfer payment for the purpose of regional redistribution may be invalid <sup>[15]</sup>. However, since the program is mainly implemented and coordinated within a country, it is more operable than Scheme 1.

In contrast, the institutional design of Scheme 4 seems to be freer and more coordinated. Although the scheme was once influenced by uncertain factors and opposed by developing countries, some developed countries have carried out theoretical research on the design of Scheme 4, and the theoretical basis and design ideas have been determined. In terms of implementation, domestic tax and border-tax adjustment do not need to be negotiated by many countries, and the implementation details of the plan are determined by sovereign countries <sup>[9]</sup>. Although it is likely to cause trade frictions, there is no doubt about its strong operability. The EU's measures to regulate the border carbon emission rights have provided reference for the implementation of border carbon tax regulation.

In general, when it comes to operability, Scheme 4 should be the best, followed by scheme 2 and scheme 3, and scheme 1 is the most difficult.

### 3.5. Discussion

According to the above analysis, the comparison results of the four dimensions are summarized in **Table 3**. The symbol ">" means better than; "≥" means may be better than or equal to, "≈" means approximately equal to.

**Table 3.** Results of the comparative analysis

Dimensions	Scheme 1
Cost-effectiveness	$1 > 3 \geq 2 > 4$
Fairness	$1 \approx 2 \approx 3 > 4$
Participation	$2 > 1 \approx 3 > 4$
Operability	$4 > 2 \geq 3 > 1$

According to the conclusion of the above four dimensions, the order of optimal, sub-optimal, medium and low, the values are assigned to score 4, 3, 2 and 1 respectively. The assignment results are summarized in **Table 4**. Through a simple assignment, it can be found that there is almost no difference in the scores of the first three schemes, while the score of Scheme 4 is significantly different from those of the first three schemes. Does this mean that Scheme 1, 2, 3 have the same degree of advantages and disadvantages, while the performance of the fourth scheme must be worse? This issue requires further discussion.

**Table 4.** Comparison of International Carbon Tax Schemes

Comparison point	Scheme 1	Scheme 2	Scheme 3	Scheme 4
Cost-effectiveness	4	2	3	1
Fairness	4	4	4	1
Participation	3	4	3	1
Operability	1	3	2	4
Total	12	13	12	7

## 4. Conclusion

The purpose of this dissertation is to do a research review of international carbon tax. International carbon tax schemes can be divided into four categories according to the existing proposals. From the theoretical analysis results of four dimensions, the first three schemes seem to be better, and the fourth scheme seems the worst. However, the first three schemes need certain preconditions which are quite difficult to meet all at the same time, while Scheme 4 is more easily implemented without necessary prerequisites and widely favored by the international community. Therefore, the discussion indicates that the process from Scheme 4 to the first three schemes is most likely to be realized.

This dissertation has a certain subjectivity and needs more further research and verification in the field of time and space. In addition, this study cannot include all variables. The content analysis also tends to be narrowed to some specific countries so that ignoring other factors that have not been taken into account. In view of the differences in institutional mechanism, social structure, industrial culture, the conclusion may not be effective under any circumstances. A more comprehensive and systematic research may be needed in the future, involving the experience and practice of more economies, breaking through the theoretical level, so as to make the international carbon tax research more practical and valuable.

## Disclosure statement

The author declares no conflict of interest.

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# The Impact of Cash Dividend Ratio on Stock Pricing: An Empirical Study of A-share Companies with High Dividend Payout

Jiazhong Feng\*

University of Warwick, Coventry, CV4 7AL, United Kingdom

*\*Author to whom correspondence should be addressed.*

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**Abstract:** This study selected 45 A-share listed companies that have paid dividends for five consecutive years from 2019 to 2024, with an average dividend yield of at least 3%, as the sample. Using a panel data model, the effect of the cash dividend ratio on stock pricing was analyzed. The empirical results indicated a significant positive relationship between the cash dividend ratio and stock price. Furthermore, stocks with high dividend payouts demonstrated greater resilience during macroeconomic downturns, while notable differences were observed across industries. These findings provide a theoretical foundation for investors in making informed decisions and offer practical guidance for listed companies in formulating effective dividend policies.

**Keywords:** Cash dividend ratio; Stock pricing; A-share market; Macroeconomics; Industry differences

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## 1. Introduction

### 1.1. Research background

Annual A-share dividends have maintained year-on-year growth for many consecutive years. In 2024, the total A-share dividends exceeded 2.3 trillion-yuan, A record high, among which the banking industry is still the main force of dividends, dividends of 631.5-billion-yuan, accounting for 45% of industry profits. This data highlights the importance of cash dividends in the A-share market. Pegged to the refinancing of share out bonus, from 2001 to 2013 differential line of share out bonus, and in 2023 the new “the nine clear” for many years not share out bonus or dividend ratio is low limit major shareholders holdings and implementation of risk warning, deterrent policy significantly enhanced. Recently, the CSRC since 2025 to implement ST regulation, forced dividends disclosure reasons, reversed transmission enterprises increase the rate of dividend. However, there is still a contradiction of “emphasizing financing over return” in the market. Investors’ demand for stable cash flow is in sharp contrast to the instability of dividend policy of listed companies. In this background, study the effect of cash

dividend proportion of stock pricing is of important theoretical and realistic significance.

## **1.2. Research significance**

From the theoretical level, this study fills the cross-trade and blank in the research of effect of share out bonus for a long period of time. Most of the existing studies focus on single industry or short-term data, and lack dynamic analysis of macroeconomic variables and industry attributes. At the same time, also can verify the validity of the financial pricing theory, the expansion of the border for the research of the finance, and more.

From the practical level, the results of the study can provide decision-making reference for market participants. To reveal the pricing rules of high-dividend companies, provide quantitative basis for institutional investors, individual investors and long-term investors such as pension funds and insurance funds, and reduce the interference of speculation on stock prices. To guide scientific and rational dividend policy of listed companies, to avoid “excessive bonuses” or “insufficient dividend” the negative impact on the stock price, power regulation policy optimization for regulators optimization. Suggestions, such as strengthen the constraints of “making”, perfecting the tax incentives, promote the A-share market from the “dominant” financing to investment and financing balance.

## **2. Literature review**

### **2.1. Market effect of dividend policy**

In foreign studies, Lintner found that companies tended to maintain stable dividends to convey profit signals <sup>[1]</sup>. Pettit confirmed that dividend announcement caused short-term stock price fluctuations <sup>[2]</sup>. In domestic research, Chen pointed out that cash dividend is conducive to attracting institutional investors <sup>[3]</sup>. Wei found that when the dividend yield was more than 3%, the proportion of long-term investors increased <sup>[4]</sup>. Yang points out that the cash dividends of listed companies' performance passed information about earnings, effect on share price information content have significantly increased <sup>[5]</sup>. Li *et al.* found that half a mandatory dividend policy for refinancing with refinancing needs or potential demand growth and competitive industry of listed companies has brought certain negative impact <sup>[6]</sup>. The research provides a basis for understanding the market effect of dividend policy, but the lack of in-depth analysis of industry difference and macroeconomic variables.

### **2.2. Threshold effect of dividend ratio**

Yu has found that when the dividend yield exceeded 3%, the support effect of dividend on stock price was significantly enhanced <sup>[7]</sup>. Yu and Liu both pointed out that the level of share out bonus of 30% there would be a watershed, broke beyond that was unencouraged in the absence of urgent need <sup>[8]</sup>. Wang further pointed out that the stability of dividends in the banking industry was better than that in the manufacturing industry <sup>[9]</sup>. Xie and Li's study showed that proportion of share out bonus policy driven threshold effect <sup>[10]</sup>. However, the existing study did not reveal industry attribute to adjust the effect of share out bonus, nor dynamic analysis macroeconomic variables affect dividend policy.

### **2.3. Cash dividend and stock pricing**

Frankel and Lee pointed out that stock mispricing can be quantified by calculating the deviation between intrinsic value and market value <sup>[11]</sup>. Liu and Han found that continuous cash dividends can reduce stock mispricing and investor opinion disagreement <sup>[12]</sup>. Song *et al.* confirmed that stable cash dividend policy can improve the

correlation between stock return volatility and fundamental information<sup>[13]</sup>. Yang and Chen pointed out that the larger the company size is, the better the continuity of cash dividend will be<sup>[14]</sup>. Zou and Feng pointed out that cash dividend of A-share listed banks has A short-term boost effect on stock price, but the long-term impact depends on the capital supplement requirement<sup>[15]</sup>. However, these studies did not involve the mechanism of cash dividend's impact on stock pricing efficiency, nor did they provide rigorous empirical evidence.

Based on the above analysis of the related literature at home and abroad, sort out the problems existed in the research and worthy of reference, this paper proposed A share for five consecutive years in 2019–2024 dividend and the dividend yield of 3% or more 45 listed companies as samples, through panel data model to the analysis of the effect of cash dividend proportion of stock pricing.

### **3. Theoretical analysis and hypothesis**

#### **3.1. Mechanism of action**

Based on the analysis of the impact of cash dividend ratio on stock pricing, the mechanism of the impact of cash dividend on stock price is first proposed.

##### **3.1.1. Direct income effect**

According to the dividend discount model (DDM), high dividend reduces the rate of return required by investors and pushes up the stock price<sup>[16]</sup>. For example, if a company pays a stable dividend every year, investors are more optimistic about future cash flow and are willing to pay a higher price to buy shares.

##### **3.1.2. Signal transmission effect**

Stable dividend sends a signal of abundant cash flow to the market and reduces information asymmetry<sup>[1]</sup>. When a company announces an increase in dividend, the market may think that its profitability and cash flow are better, thus raising the stock price.

##### **3.1.3. Valuation restructuring effect**

In the low-interest rate environment, the relative attractiveness of stocks with high dividend yield increases, and the valuation is repaired. In the current era of low interest rates, high-dividend assets have become an important choice for investors to seek stable returns.

#### **3.2. Research hypothesis**

This paper proposes specific research hypotheses based on the analysis of the impact of cash dividend ratio on stock pricing.

- (1) H1: Cash dividend ratio is positively correlated with stock pricing. That is, high cash dividend ratio attracts value investors to increase their holdings by sending signals of financial stability, and improves pricing efficiency under the guidance of policies, thus forming a positive linkage between dividend ratio and stock price.
- (2) H2: The support effect of dividend stability on stock price is stronger than the absolute level.
- (3) H3: During the economic downturn, the stock price of companies with high dividend is more resilient.
- (4) H4: The high dividend policy in mature industries (such as banks) has a more significant effect on boosting stock prices.

## 4. Research design

### 4.1. Sample scope

The sample screening criteria for this paper are as follows:

- (1) Time range: 2019–2024 (covering the period of COVID-19).
- (2) Company screening criteria: (a) Dividends for five consecutive years from 2019 to 2024; (b) Average annual dividend yield  $\geq 3\%$ ; (c) The revenue and net profit in 2024 shall not be less than 85% of that in 2019; (d) ROE for the past five years shall be  $\geq 10\%$ . The final eligible sample included 45 companies, covering 12 industries, including banking, basic chemicals, machinery, and equipment.
- (3) Data source: Wind database and CSMAR database to ensure the authority and reliability of the data.

### 4.2. Definition of variables

To conduct quantitative analysis, this paper collected 19 financial and market indicators, including the logarithm of the annual average closing price, total annual cash dividend, net profit, and the logarithm of total assets. The dependent variable in the model was stock pricing, measured by the logarithm of the annual average closing price ( $\ln Price$ ). The core explanatory variable is the cash dividend ratio (Dividend Ratio), defined as the ratio of total annual cash dividends to net profit. Several control variables are also included to account for firm-specific and market-related factors. Firm characteristics include Size (the logarithm of total assets), Leverage (asset-liability ratio), and profitability (ROE). Market environment factors include Market Return, represented by the annual return of the CSI 300 Index, and Risk-Free Rate, proxied by the 10-year Treasury yield. Additionally, 11 industry dummy variables (Industry Dum) are introduced based on the industry classification defined by the China Securities Regulatory Commission (CSRC) to control for industry-specific effects.

### 4.3. Model construction

The empirical analysis of this paper adopted the dynamic panel fixed effect model according to the analysis purpose and data type.

$$\ln Price_{it} = \alpha_0 + \alpha_1 DividendRatio_{it} + \sum_{k=2}^n \alpha_k Control_{kit} + \gamma_t + \varepsilon_{it}$$

Where  $i$  denotes company,  $t$  denotes year,  $\gamma_t$  denotes time fixed effect, and  $\varepsilon_{it}$  denotes random error term. In order to deal with the endogeneity problem, instrumental variables (such as one-period-lagged dividend ratio and one-period-lagged control variables) are introduced, and system GMM estimation is used to estimate the model.

### 4.4. Empirical method

#### 4.4.1. Grouped regression

This paper tested by industry (banking / non-banking) and business cycle (GDP growth  $\geq 6\%$  /  $< 6\%$ ). The adopted model was as followed.

$$\ln Price_{it} = \alpha_0 + \alpha_1 DividendRatio_{it} + \sum_{k=2}^n \alpha_k Control_{kit} + \gamma_t + \varepsilon_{it}$$

#### 4.4.2. Interaction term analysis.

The interaction term of dividend ratio  $\times$  GDP growth rate was to introduced to analyze the moderating effect of macro economy on dividend effect. The adopted model was as followed.

$$\ln Price_{it} = \alpha_0 + \alpha_1 DividendRatio_{it} * GDP + \sum_{k=2}^n \alpha_k Control_{kit} + \gamma_t + \varepsilon_{it}$$

#### 4.4.3. Robustness test

To replace explained variables such as the log *lnPrice* of stock price after replaced by P/E ratio, the model was as followed. Excluding the year of COVID-19 impacted. The instrumental method was used.

$$P/E_{it} = \alpha_0 + \alpha_1 DividendRatio_{it} + \sum_{k=2}^n \alpha_k Control_{kit} + \gamma_t + \varepsilon_{it}$$

## 5. Empirical results and analysis

### 5.1. Descriptive statistics

The descriptive statistics of the sample companies showed that the average dividend ratio was 32.7%, the median dividend yield was 4.1%. In terms of industry distribution, 12 banks (26.7%), 8 basic chemicals (17.8%) and 6 public utilities (13.3%) were favorable for the analysis of industry differences. In terms of profitability, the mean value of ROE was 12.8% and the standard deviation was 2.4%, indicated that the sample companies had high profitability stability.

### 5.2. Main regression analysis

Use Eviews13.0 regression analysis software, the core, according to the results of the core variable Dividend Ratio coefficient was 0.12 ( $p < 0.01$ ), indicating that under 1% significance level, the regression analysis results support H1: cash dividend ratio and stock price are related. Control variable, the ROE coefficient was 0.21 ( $p < 0.01$ ), Market Return coefficient was 0.35 ( $p < 0.01$ ), both are significant positive correlation; The Leverage coefficient was -0.05 ( $p < 0.1$ ), which was significantly negative correlation. In terms of economic significance test, it can be found that for every 1% increase in dividend ratio, the logarithm value of stock price increases by 0.12% on average, which is equivalent to 12.7% increase in stock price.

### 5.3. Grouping test

In view of Hypothesis 3 and Hypothesis 4 proposed in the previous section, the group regression method is adopted here, and the dynamic panel fixed effect model is still used to conduct regression on different groups respectively.

#### 5.3.1. Industry differences

By grouping regression methods for different industry grouping test, the following conclusions: banking Dividend Ratio coefficient was 0.18 ( $p < 0.01$ ), significantly higher than that of manufacturing Dividend Ratio coefficient was 0.09 ( $p < 0.05$ ), support for H4: High dividend policy in mature industries (such as banks) has a more significant effect on stock price. Case study: Industrial and Commercial Bank of China paid out 109.773 billion yuan in dividends, with a stock price increase of 12.1%, while the average increase of manufacturing companies in the same period was only 8.3%.

#### 5.3.2. Economic cycle differences

Group regression method is used for grouping different economic cycle test, the following conclusions: economic downward legs (GDP growth rate  $< 6\%$ ), dividend ratio coefficient is 0.15 ( $p < 0.01$ ), higher than that of the date on dividend ratio coefficient of 0.08 ( $p < 0.1$ ), support H3: In the economic downturns, the stock price of companies with high dividend payout is more resilient.

Case: With a GDP growth rate of 5.2% in 2024, China Merchants Bank accumulated a dividend of RMB20.6



billion from 2019 to 2024, with an average annual dividend ratio of 33.2% and a stock price increase of 18.6%, significantly higher than the average level of the banking industry (12.3%).

## **5.4. Robustness test**

In order to ensure the reliability of the above regression results, the paper needs to conduct a robustness test. The instrumental variable method is adopted for different explained variables, failed sample periods or the introduction of instrumental variables to observe whether the conclusions change.

### **5.4.1. Replaced of explained variables**

P/E ratio ( $P/E$ ) = price/earnings per share, reflect market expectations of future earnings to the company. Share prices logarithmic mainly reflects the absolute level of change, and the p/e ratio will share price and profit together, can be more comprehensive to reflect the market valuation of the company. For example, the two companies share price is the same, but high earnings, a low p/e ratio, market perceive their valuations are relatively low, the future may have more potential; The other company has low earnings and a high P/E ratio, which may indicate that the market has a high expectation of its future earnings growth. Therefore, from the economic meaning, P/E ratio can be used as an alternative indicator to study the market valuation related issues. Replace shares logarithm based on p/e ratio ( $PE$ ), regression results showed dividend ratio coefficient is significantly positive ( $0.07, p < 0.05$ ).

### **5.4.2. Adjusting the sample period**

Considering the impact of COVID-19, the core regression conclusions still do not change substantially after excluding the impact years of the epidemic in 2020.

### **5.4.3. Instrumental variable method**

Considering the core may exist endogenous variables, here directly to the industry average ratio as a tool of share out bonus variables, using instrumental variable method for regression analysis, the regression conclusion still there was no significant difference, and excessive identify constraints test (Sargan statistic = 1.23,  $p = 0.27$ ).

## **6. Case study: The dividend effect of bank stocks**

### **6.1. Case study of China Merchants' Bank**

Using China Merchants Bank as a representative case, the analysis highlights the impact of dividend policy on stock price performance. From 2019 to 2024, the bank distributed a cumulative dividend of RMB 20.6 billion, maintaining an average annual dividend ratio of 33.2% and a stable dividend yield between 4% and 5%, reflecting a consistent and shareholder-friendly dividend policy. In 2024, the stock price of China Merchants Bank increased by 18.6%, significantly outperforming the average growth rate of 12.3% observed in the broader banking industry. To further investigate this relationship, a time series econometric regression model was employed, with the results showing that the coefficient of the cash dividend ratio (Dividend Ratio) is 0.21 and statistically significant at the 1% level ( $p < 0.01$ ). This indicates that the bank's high dividend policy has a strong and positive effect on its stock price performance.

### **6.2. Industry comparison**

A comparison between the banking and manufacturing industries reveals notable differences in dividend policy

and stock price behavior. The banking industry demonstrates a relatively high average dividend ratio of 32.7%, coupled with strong stability as indicated by a low standard deviation of 4.2%. This reflects a consistent payout approach and aligns with the industry's reputation for offering defensive investment characteristics, including notable stock price resilience during market fluctuations. In contrast, the manufacturing industry shows a lower average dividend ratio of 25.3% and significantly higher volatility, with a standard deviation of 8.1%. This suggests a less stable dividend policy, and stock prices in this sector tend to be more sensitive to macroeconomic changes, making them more susceptible to external shocks and economic cycles.

## **7. Conclusion and suggestion**

### **7.1. Research conclusion**

Based on the research hypotheses and empirical analysis, several key conclusions can be drawn. First, there is a significant positive correlation between the cash dividend ratio and stock pricing among A-share listed companies, indicating that firms with higher dividend payouts tend to enjoy more stable stock price performance. Second, grouped regression analysis across different economic cycles reveals that companies with high dividend policies demonstrate greater stock price resilience during periods of macroeconomic downturn, highlighting the defensive characteristics of such firms. Third, industry-level grouped regression tests suggest that industry attributes moderate the effect of dividend policy on stock pricing. Specifically, the positive impact of high dividend policies is more pronounced in mature and stable industries, such as banking, where consistent dividends are valued more highly by investors. These findings collectively support the view that dividend policy plays a critical role in influencing investor perception and stock market performance, particularly under varying economic and industry conditions.

### **7.2. Practical suggestion**

In light of the research findings, several practical recommendations are proposed for key market participants. For investors, the significant positive correlation between the cash dividend ratio and stock pricing, as well as the observed stability in stock price performance among high-dividend firms all suggests a strategic preference for allocating capital to sectors such as banking and public utilities, particularly those with a dividend yield exceeding 3% and a strong record of stable dividend payouts. This approach can help mitigate exposure to the heightened volatility often found in cyclical industries. For listed companies, it is advisable to adopt a sustained and transparent dividend policy, which can not only enhance corporate governance and attract long-term institutional investors, but also contribute to stock price stability in line with regulatory expectations, that potentially resulting in increased policy support. Finally, regulators are encouraged to further strengthen the dividend supervision framework. In particular, requiring or encouraging listed firms to disclose forward-looking dividend plans (for the next three years) would enhance market transparency and help shift investor behavior from short-term speculation toward long-term value investing.

### **7.3. Research limitation**

Despite the contributions of this study, there are several limitations that should be acknowledged. First, regarding the sample scope, the analysis is limited to companies listed on the A-share market, without incorporating data from cross-border markets such as the Hong Kong or US stock markets. As a result, the paper does not provide a comparative perspective on how dividend policies and stock pricing behavior may differ across markets with varying regulatory environments and investor structures. Second, in terms of variable selection, the study does

not take into account ESG (Environmental, Social, and Governance) factors, which are increasingly recognized as important determinants of corporate financial policies, including dividend distribution. Future research could expand upon this by incorporating cross-market samples and exploring the role of ESG performance in shaping dividend policy and its impact on stock valuation.

## Disclosure statement

The author declares no conflict of interest.

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# Enhancing the Regulatory Framework for Financial Data Sharing Between Banks and Enterprises

Haoran Yang\*

Southwest University of Political Science and Law, Chongqing 400042, China

*\*Author to whom correspondence should be addressed.*

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**Abstract:** In the process of implementing data openness between banks and fin-tech companies, as the breadth and depth of cooperation between banks and enterprises continue to increase, there is a risk of “too much correlation to fail” and “too many links to fail”. There are problems with the implementation of financial data openness by regulatory agencies for banks and fin-tech enterprises, such as the ambiguity of regulatory responsibilities, the emphasis on financial regulatory goals, and the lag in regulatory methods. To address these issues, it is necessary to clarify the responsibilities of financial regulatory agencies, establish a collaborative mechanism for financial regulation, coordinate the types of risks in bank enterprise cooperation, achieve the technical implementation of financial regulatory measures and the design of regulatory systems, obtain regulatory data in real time, establish a hierarchical regulatory system for bank enterprise cooperation to improve the regulatory path, and ensure the rational and legal use of financial data in bank enterprise cooperation.

**Keywords:** Fin-tech companies; Bank enterprise cooperation; Financial data openness; financial regulation

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## 1. Introduction

To achieve the digital transformation of banks, multiple banks have announced the signing of cooperation agreements with fin-tech companies and have developed fin-tech through joint innovation laboratories and other means, promoting regional joint development and application of financial data, continuously improving the risk control and prevention capabilities of financial data to cope with external changes. The cooperation between banking and financial institutions, as well as fin-tech enterprises, utilizes new generation high-tech technologies such as big data and artificial intelligence to promote innovation and application of fin-tech products, build a fin-tech ecosystem with internal circulation and even external output, and enable financial data to play an increasingly important role. With the increasing demand for building high-quality financial data, banks have chosen to cooperate with fin-tech companies due to their own technological limitations. However, the openness of financial data between both parties has brought new challenges and problems to financial regulation. The ambiguity of the

responsibilities of financial regulatory agencies leads to unclear financial data governance goals, the emphasis on financial regulatory goals makes it difficult to handle the overlapping effects of technical and financial risks, and the lag in financial regulatory methods makes it difficult to conduct comprehensive supervision in the face of two-way cooperation between fin-tech enterprises. These series of problems have triggered financial arbitrage behavior between fin-tech enterprises and banking and financial institutions. Therefore, this article points out the issue of financial data openness in bank enterprise cooperation from the perspective of financial regulation, and proposes corresponding solutions to address the problem <sup>[1]</sup>.

## **2. The regulatory status and challenges of open financial data for banks and enterprises**

### **2.1. The ambiguity of responsibilities of financial regulatory agencies increases the difficulty of financial data supervision**

Financial data gradually exhibits the characteristic of “cross-border” in its development process. The utilization of data in bank enterprise cooperation determines the involvement of multiple financial regulatory departments and even other technical regulatory authorities in supervision. Regulatory agencies for financial data include the State Administration of Financial Supervision, the People’s Bank of China, and its subordinate Financial Technology Commission, the Financial Standardization Technical Committee, and other departments. The current regulatory measures for bank enterprise cooperation by financial regulators are still mainly reflected in credit cooperation, risk management, financing services, and limitations on cooperation scope, with little emphasis on the construction of mechanisms for financial data governance. Each financial regulatory department only supervises some financial data attached to the core business of supervision, resulting in overlapping responsibilities and regulatory gaps among multiple regulatory agencies <sup>[2]</sup>. The data collection and management systems under various financial regulatory departments have different standards, among which the system responsible for collecting banking financial data is the EAST on-site inspection system, which focuses on micro prudential supervision.

The National Financial Basic Database is responsible for macro prudential supervision and has been integrated with various legal entities engaged in credit business, such as commercial banks, consumer finance companies, and small loan companies. By summarizing various financial data, it achieves targeted and accurate financial regulation. While the People’s Bank of China has established a unified financial statistical database to collect and process financial statistical data reported by financial institutions, the 1104 system of the CBRC is only responsible for collecting relevant data of the banking and insurance industries. This classified data collection method conflicts with the cross-use of financial data, resulting in overlapping and omission of data collection. Some fin-tech companies that cooperate with banking and financial institutions need to submit their internal data to the financial basic database <sup>[3]</sup>. Banking and financial institutions need to submit their internal financial data to both the EAST system and the national financial basic database. This multi-head data submission method not only increases the burden on banking and financial institutions, but also makes data submission more decentralized. This limits the scope of data collection and regulatory coverage, and incomplete and incomplete data collection by various regulatory agencies directly leads to a decline in the efficiency of financial data governance <sup>[4]</sup>.

Even though banks are aware that some data in fin-tech companies is obtained through theft, illegal collection, and other means, whether it is national banks or regional small and medium-sized banks and other funding institutions, due to the lack of technical and infrastructure support, customers rely more on fin-tech companies for access, and the autonomy and discourse power of banks themselves are constantly weakened. However, banks



have the advantages of long-term accumulation of financial data, credit, and capital, and can rely on financial technology enterprises to carry out comprehensive cooperation to complete their digital transformation. However, financial technology has virtuality, concealment, and the existence of financial data black boxes. Even though the “Guidelines for Data Governance of Banking and Financial Institutions” stipulate that banking regulatory authorities should continuously supervise the data governance of banking and financial institutions through off-site supervision and on-site inspections, they still cannot monitor the dynamic situation of financial data in real time <sup>[5]</sup>. Banks may give up their investigative power due to rent-seeking and other reasons. Some fin-tech companies, in the absence of financial regulation, rely on the supply of data as a key element, using their advanced technological means and advantageous market position to attract other financial institutions to cooperate and gain profits. In this process, they further expand their data assets and form barriers by increasing user conversion costs and data migration costs, thereby exacerbating the fragmentation of the financial service system.

The Commercial Bank’s Application Program Interface Security Management Specification issued by the People’s Bank of China specifically stipulates the access rules for the application parties (including third-party institutions), and the commercial banks are responsible for conducting multi-dimensional inspection of third-party cooperation institutions. However, due to the lack of corresponding reference indicators and specific review requirements, this has brought great convenience to the banks, and it is difficult to be fair and just to all third-party institutions applying for cooperation in practice. If the regulatory obligation of third-party review is fully entrusted to banks, driven by the competitive interests of financial technology, banks are likely to be monopolized by one of the cooperating institutions, and specific subject policies are given preferential treatment, leading to exclusivity and suppressing competition. Banks and fin-tech companies are more willing to build a financial ecosystem centered around themselves, enhance the breadth, diversity, and inclusiveness of their services, and circulate financial data internally to hinder financial data sharing <sup>[6]</sup>.

Fin-tech companies lack regulation on the utilization of financial data in the banking industry. Financial technology platforms have access to a large amount of core financial data, which continuously accumulates to form financial data assets. Once there is data pollution or risk, it can be transmitted to banking and financial institutions through the data chain. Under the leadership of fin-tech companies, which aim to compete for customer resources and expand their business scope, they may engage in the misuse of financial data and give preferential treatment to proprietary products without the knowledge of banks, to maximize their own interests <sup>[7]</sup>. The big data processing technology and scenario services provided by some fin-tech companies that cooperate with banking and financial institutions have played an important role in financial activities. The compliance and stability of their operations are also closely related to the financial regulatory goals of preventing financial risks and protecting financial consumers. As financial data sharing becomes the industry norm, fin-tech companies may have more information about consumers’ personal and financial lives. When personal financial data is combined with other datasets, this enormous amount of information can easily be used for unethical business purposes <sup>[8]</sup>.

In the era of digital finance, data should become the core of financial regulation, but these fin-tech companies that hold financial data are rarely regulated by financial regulatory agencies. The regulatory efforts do not match the current financial situation, the uneven allocation of financial regulatory resources leaves a large space for arbitrage behavior of fin-tech companies <sup>[9]</sup>. Due to the technological differences and conflicts of interest between banks and fin-tech companies, fin-tech companies may violate contractual agreements by illegally abusing, analyzing and modeling financial data, developing products, sharing transactions, etc., to seek personal gain <sup>[10]</sup>. For example, fin-tech enterprises use the data obtained from banking financial institutions to provide user credit

risk assessment for their own Internet credit business or the business of other financial institutions, and directly obtain benefits <sup>[11]</sup>.

Whether the use of financial data obtained by fin-tech companies will exceed the agreed scope of banking and financial institutions, whether the banking industry is aware of the ultimate use and depth of processing of their open financial data, and other issues may be ignored due to the complex structure, technological black box, and dominant role of fin-tech companies in cooperation with banking and financial institutions. Even though the country has introduced multiple laws and regulations to strengthen the supervision of financial data, the risks caused by financial data may not necessarily be from the banking and financial institutions as the source of risk. The existing regulatory schemes still mainly focus on market-based solutions and regulatory schemes, including behavioral constraints on individual financial institutions, seriously neglecting the supervision of fin-tech enterprises <sup>[12]</sup>.

## **2.2. The emphasis on financial regulatory objectives is difficult to cope with the combined effects of financial and technological risks**

Fin-tech companies themselves have strong professionalism and technicality, as banks have massive undeveloped financial data and weak financial data development capabilities, making it difficult to achieve deep data mining. Therefore, cooperation between banks and fin-tech companies can make up for the shortcomings by relying on emerging technologies such as cloud computing, artificial intelligence, and block-chain from fin-tech companies to develop algorithms to guide financial consumers in implementing financial behavior. But algorithms are not only based on technical rationality, but also mixed with the irrational thinking of algorithm designers. If algorithm designers fail to consider other key factors or have serious biases, it may cause technical defects, financial data abuse, algorithm bias, and other problems, leading to erroneous trading behavior of financial consumers. For example, in big data credit reporting, due to deviations in data quality or design flaws in algorithms, discriminatory or erroneous credit evaluation conclusions may be generated, which increases the burden on financial consumers to distinguish the authenticity of information <sup>[13]</sup>.

In the context of financial technology, banks and financial technology enterprises are more focused on cooperation in financial data and other aspects. Based on the current technological level of financial technology enterprises, financial data can be efficiently processed in real-time. However, if there are risks in data processing, cross industry transmission effects will occur more quickly, causing new real-time risks. Due to the closer connection between banks and fin-tech companies in terms of technological connectivity, financial business intersection, and inter-connectivity of financial data, technical vulnerabilities or programming errors in fin-tech companies can quickly ripple through the banking and financial institutions, thereby generating new systemic risks to the entire financial market <sup>[14]</sup>. Defects in internal controls and data systems may also lead to unforeseeable losses. Financial technology companies cooperate with multiple banking and financial institutions. Once the financial technology system built by both parties is breached, the related financial business system will be paralyzed in a short period of time. Technical risks may escalate from quantitative changes to qualitative changes in specific situations, and may even trigger potential systemic risks, affecting financial stability. The business of banking and financial institutions has begun to shift significantly from offline to online.

Financial technology companies can provide software and hardware facilities with higher performance and stronger technical level as support. If a system node fails, under the influence of data, it will quickly spread from financial technology companies to the banking system, increasing the difficulty for regulatory agencies to handle

<sup>[15]</sup>. At present, the goal of financial regulation still remains in the traditional financial business field, with a focus on regulating enterprise financing, payment settlement, fund management cooperation, and other aspects. Due to the rise of financial technology, in addition to traditional financial risks such as market risk, credit risk, and systemic risk, financial risks accompanied by technological risks have made financial regulation more complex. However, the current means of financial regulation are difficult to cope with the combined effects of technological and financial risks. The cooperation between banks and enterprises has increased the risk correlation between fin-tech companies and banks, especially when fin-tech companies with the same or similar business models provide fin-tech services to multiple banks simultaneously, the risk correlation between different banks will increase <sup>[16]</sup>. fin-tech platforms use financial data to create a technological chain that links multiple banking and financial institutions with other fin-tech companies, forming a financial ecosystem that makes it easier for a certain institution's risks to spill over and spread faster through the financial ecosystem <sup>[17]</sup>.

### **2.3. The lag of regulatory methods makes it difficult to cope with arbitrage risks in two-way cooperation between enterprises**

The continuous innovation of financial technology has increased the difficulty of financial data regulation, which requires continuous improvement and enhancement of regulatory technology. The business of financial technology enterprises has expanded from cooperation with banks in financial business to cooperation with financial regulatory agencies in regulatory technology, resulting in a situation of two-way cooperation among the same financial technology enterprise. Regulatory technology products have also been introduced into the technology information system of financial institutions to reduce compliance costs. This two-way cooperation model directly increases the occurrence of moral hazard in financial technology enterprises. Bank enterprise cooperation may lead to fin-tech companies reserving regulatory gaps for their cooperative businesses in order to achieve regulatory arbitrage. fin-tech companies gain the identity of implicit regulators by collaborating with financial regulatory agencies <sup>[18]</sup>.

The cooperation between fin-tech companies and banking and financial institutions directly increases the possibility of fin-tech companies becoming data thieves and regulatory arbitrageurs, becoming potential drivers of financial data risks and regulatory loopholes. Especially in terms of regulatory data security protection, once the loopholes in regulatory data and regulatory technology are mastered by fin-tech companies, the difficulty of financial data regulation in bank enterprise cooperation will significantly increase. Whether it is banking and financial institutions or financial regulatory agencies, their financial technology innovation and application, as well as the iterative upgrading of technology, rely more on financial technology enterprises. Therefore, financial technology enterprises have stronger advantages in the cooperation process. Currently, there is still a lack of disclosure of shared financial data and the scope of data use in bank enterprise cooperation. Deviations in the focus direction and regulatory measures of regulatory agencies can easily lead to regulatory mismatches.

## **3. International experience in regulating the opening of financial data between banks and enterprises in cooperation**

### **3.1. Regulatory measures taken abroad for financial data openness in cooperation between banks and enterprises**

The European Union's Payment Services Directive (PSD2) requires banks to open customer data to third parties, but fully regulates payment initiation service providers (companies that initiate online payments using customer

accounts) and account information service providers (companies that aggregate account data from financial institutions and use this data to provide services), filling the regulatory gap for emerging financial technologies. PSD2 requires that when banks cooperate with third-party institutions, financial institutions can only grant access to third-party service providers with the personal consent of account holders and cannot refuse <sup>[19]</sup>. The law grants individuals great freedom in the disposal of financial data. The Payment Services Directive II requires third-party institutions to register with regulatory authorities in their member states and meet certain prudential and security requirements, but prohibits third-party institutions from accessing, storing or using any services unrelated to customer data, and guides the European Banking Authority and the European Central Bank to develop supplementary regulatory standards for data security, data access and transaction monitoring <sup>[20]</sup>.

The UK has developed the Open Banking Standards Framework and put forward specific requirements. One is API standards, which suggest using open APIs for bank transactions, but only with the consent of the data owner can private data in the open APIs be accessed, and technical and security standards must also be followed. The second is to classify the data and grant different data sharing permissions to third-party institutions based on the type of financial data and the nature of bank enterprise cooperation. Thirdly, establish safety standards. The process of sharing data between banks and third parties must obtain user consent. The fourth is to establish independent institutions to track and supervise the implementation of open banking standards, granting them the power to review third parties. The British Standards Institute has released the “Guidelines for Supporting Cooperation between fin-tech Companies and Financial Institutions” standard, which proposes that financial institutions and fin-tech companies should conduct due diligence on the feasibility and safety of cooperation before starting cooperation. fin-tech companies should provide relevant information on whether they have regulatory authorization. If they are punished by regulatory agencies, they should promptly disclose the specific reasons for the punishment and other details. Both parties should work together to ensure that cooperation is carried out in a legal and compliant manner. The Financial Conduct Authority is responsible for certifying and licensing all financial service providers involved in bank cooperation. If a partner wants to obtain financial data from a bank, they need to register with the Financial Conduct Authority. Only by passing the testing system of the Financial Conduct Authority and obtaining regulatory permission can they obtain the qualification to access bank customer data <sup>[21]</sup>.

The Australian Treasury Department suggests that regulatory agencies classify bank data and set different open requirements, clearly stipulating that customer provided data, transaction data, etc. fall within the scope of data sharing, while high-risk data cannot be included in the scope of bank data sharing. The Australian Prudential Regulation Authority indirectly regulates fin-tech companies, primarily banks. If a bank’s deposit or wealth management business uses fin-tech, the fin-tech companies it collaborates with are also included in the regulatory scope. Hong Kong’s financial management has granted banks the autonomy to choose which fin-tech companies can access their internal data unilaterally, and contractual terms should be established between banks and companies to mitigate the risk of customer data being abused.

### **3.2. Summary of foreign experience**

One is to focus on conducting prior censorship of bank cooperation partners. Due to the diverse types of partners involved in bank cooperation and their involvement in various financial businesses, it is difficult to control the purpose and scope of financial data usage. Therefore, it is necessary to conduct a feasibility review of the cooperation partners and their contents beforehand to ensure that the cooperation is legal and compliant. The



second is to grant individuals great freedom of data disposal. The EU requires that anyone who intends to access financial institution-related data should obtain permission from the account holder. Even if the financial institution is a data holder, its disposal authority over financial data is still limited. The data disposal authority of financial institution account holders is much greater than that of financial institutions as data holders, ensuring the security and legality of financial data use. The third is to classify financial data, set different regulatory standards, and clarify the scope of data sharing. Fourthly, financial technology companies participating in cooperation will also be included in the scope of financial regulation, with the aim of achieving comprehensive supervision of banking and financial institutions and ensuring the security of financial data.

## **4. Suggestions for improving the supervision of financial data openness between banks and fin-tech enterprises**

### **4.1. Establish a multi departmental vertical financial regulatory coordination mechanism to expand regulatory scope**

Establish a vertical linkage regulatory model between financial data centers and the State Administration for Financial Regulation. The People's Bank of China has set up a national financial basic data center to provide core data support for the macro-control of financial regulators and establish a unified national financial basic database. In the Plan for the Reform of Party and State Institutions, it is proposed to establish the State Financial Supervision and Administration to take unified responsibility for the supervision of the financial industry except the securities industry. The decentralization of responsibilities among financial regulatory agencies has led to a fragmented state of financial data supervision. Therefore, it is necessary to build and operate a unified financial data supervision platform. The national financial basic database established by the financial basic data center integrates EAST on-site inspection system, 1104 system, People's Bank of China financial statistical database and other financial data collection systems, collects financial data from all financial institutions and their partners, achieves the goal of "collecting the same data only once for supervision", and classifies and manages all data. The financial data center constructs a model for data analysis and risk monitoring rating.

The "Data Article 20" points out the need to promote cross-regional, cross-departmental, and cross-level collaborative linkage. However, at the horizontal regulatory level, multi-departmental regulation leads to overlapping or regulatory gaps in financial regulation. Based on the experience and lessons learned from the UK regulatory collaboration practice, relying solely on informal cross-departmental collaboration mechanisms is not sufficient to promote effective cooperative regulatory actions. Therefore, it is extremely necessary for the Financial Basic Data Center to cooperate vertically with the State Administration of Financial Supervision and Administration. The Financial Basic Data Center manages the financial basic database, collects data uniformly, and classifies and grades the data to ensure data continuity and consistency, establish unified financial data management standards, and achieve dynamic supervision of data.

The State Administration of Financial Supervision and Administration has an internal department for non-bank institution supervision and a department for bank supervision, which is responsible for coordinating and overseeing the cooperation between banks and fin-tech enterprises. The Financial Basic Data Center has established an information sharing mechanism with the State Administration for Financial Regulation to ensure the timeliness and effectiveness of information acquisition by the State Administration for Financial Regulation. Open financial data will be applied to financial technology research and development, financial product innovation, and various cooperative financial businesses. Therefore, in the digital economy era, financial regulatory agencies



not only supervise financial data, but also need to fully cover cooperative businesses. The State Administration of Financial Supervision and Administration can achieve cross-regional and cross-industry supervision of financial products and financial technology. In the context of financial technology, the focus should be on building technology and business compliance systems to achieve automation and intelligence of supervision. The financial basic data center should use network and data security facilities and management systems, such as data encryption protection and post-disaster data recovery to prevent data security risks and prevent data flow risks caused by cross-industry financial data.

Due to the complex nature of fin-tech companies, the State Administration for Financial Regulation should define the scope of enterprises that cooperate with banks, establish a blacklist system to limit banks' choice, blacklist fin-tech companies that violate regulatory regulations or pose operational risks, and regularly publicize them to the market. Banks should conduct risk assessments with cooperative enterprises on their own and file them with the State Administration of Financial Supervision and Administration. Financial technology enterprises that cooperate with banks should be included in the regulatory scope of the Financial Supervision and Administration. Financial technology enterprises that participate in cooperation are required to submit data reports to the financial data center on a regular basis to ensure the comprehensiveness of the coverage of the financial basic database. The financial regulatory authority should establish a specific due diligence process for bank-enterprise cooperation and require both banks and fin-tech companies to jointly establish a comprehensive financial risk control system. A continuous monitoring plan should be established for the use of financial data to ensure the legality, completeness, and predictability of the cooperation between the two parties.

At present, under the global financial regulatory framework, there are two main regulatory models for third-party institutions. The first is for bank regulatory authorities to directly supervise third-party institutions, and the second is for financial regulatory authorities to sign contracts with third-party institutions. Regardless of the method, financial regulatory authorities require banks to conduct continuous risk monitoring of third-party services. At the international level, the authorization for third-party institutions has been granted to banks, which provides great convenience, comprehensiveness, and efficiency for banks to supervise their partners. The financial regulatory authority should grant banks regulatory authority over their partners and require banks to regularly report to the financial regulatory authority.

Financial data combines privacy and publicity. Privacy is because the financial data of banks and fin-tech companies can reflect an individual's financial status, consumption level, etc. While publicity stems from the full release of the value of financial data, which can promote digital transformation and improve the research and development capabilities of fin-tech products between banks and enterprises to better serve financial consumers. Therefore, the concept of classification and layering should be upheld for financial data, and different protection rules should be constructed from different data types. For sensitive data that may endanger personal and property safety in case of leakage, illegal provision or abuse, strict protection should be adopted, while for general data outside of sensitive data, loose authorization rules should be adopted to promote the interconnection and intercommunication of financial data. If both parties open up financial data, fin-tech companies and banking financial institutions should prominently inform users of the frequency, scope, and retention period of data sharing on their website homepage, and also allow users to authorize data sharing by implication. The financial regulatory authority should require banking and financial institutions to establish a data intelligence risk monitoring system, implement data quality monitoring of data within the scope of cooperation, and focus on monitoring the continuity, authenticity, and accuracy of data. Regularly conduct risk monitoring on bank partners to prevent systemic

financial risks caused by legal and regulatory risks.

## **4.2. Coordinate risk types and improve the technical level of financial regulation**

Due to the diversified regulatory targets and heavy regulatory tasks of the State Administration of Financial Supervision and Administration, there is a lack of sufficient technical level and ability to supervise all business in bank enterprise cooperation. In order to improve regulatory efficiency, it is necessary to centrally coordinate the risk types of bank enterprise cooperation, establish a risk rating system, and determine regulatory priorities based on the development laws of various risks. In the current era of rapid development of financial technology innovation, various financial businesses between banks and enterprises are becoming more ambiguous in terms of transaction objects, time, and methods. The transaction process and content lack sufficient transparency, making it easy for regulatory deviations to occur. Even if risk monitoring is automatically carried out by banks, ethical risk issues may still arise. Therefore, regulatory authorities should adopt irregular supervision methods such as non-site inspections, and comprehensively use technical risk internal control and other regulatory tools to supervise the cooperation between both parties. Due to certain differences in format, standards, and storage methods between data from fin-tech companies and data from banking and financial institutions, it is necessary to use multiple technologies for re-cleaning and integration, including standardized code value conversion, data standardization, formatting, and other operations. In addition to the traditional financial risks, regulators should focus on the financial problems caused by technical risks.

The Notice on Strengthening Network and Data Security Management in Third Party Cooperation issued by the State Financial Supervision and Administration pointed out the financial risks caused by technical defects, such as the failure of an Internet domain name agent to change without permission, which led to the failure of a bank's Internet domain name resolution, affecting financial transactions for up to 68 minutes at the peak of business. The Financial Institutions Review Board of the United States has developed a unified information technology risk rating system, mainly used to identify technology risk exposure situations. Through comprehensive and individual ratings, it quickly identifies financial institutions and technology service providers with significant technology risks, and determines corresponding regulatory strength based on this. To prevent financial problems caused by technological risks, financial regulatory authorities should also adopt risk rating methods, using machine learning, artificial intelligence, big data, and other methods to systematically evaluate the distribution of major technological risks when banks cooperate with fin-tech enterprises, effectively identify potential risk hazards, and take corresponding regulatory measures.

Due to the formation of a multi-node, high-density social network between banking and financial institutions, as well as fin-tech enterprise entities, the risk of any node default or algorithm code errors can be easily transmitted to other platforms through technology and networks, leading to systemic risks such as too fast to fail and too many links to fail. Therefore, banking and financial institutions should establish and improve their overall risk isolation mechanism with fin-tech enterprises, including risk isolation between banking and financial institutions and other banking and financial institutions, as well as between fin-tech enterprises. Strengthen the construction of "firewalls" in risk prone areas such as data, finance, and related party transactions, reasonably isolate behaviors in information technology systems, operation back-ends, and other fields, and prevent the mutual transmission of financial and technical risks caused by close ties between fin-tech enterprises and banking and financial institutions. The cooperation between banking and financial institutions, as well as fin-tech companies, involves a large amount of sensitive and personalized customer data.

Therefore, by introducing privacy computing technology, the goal is to achieve cross regional cooperation of data while protecting data security and circulation, and solving the difficulties of data protection and integrated applications. To ensure the security of financial data in the process of financial data openness, the standardization of privacy technology interconnection technology should be improved. However, due to inconsistent technical standards among partners, difficulty in determining responsibilities of all parties, and compatibility of rules between banking industry financial institutions and fin-tech enterprises in the process of financial data openness, the Technology Supervision Department of the State Administration of Financial Supervision should act as a neutral organization to coordinate and promote the collaboration of privacy computing technology. This not only ensures that both parties follow up with the requirements of financial regulators, but also achieves a balance of interests among all parties at multiple levels with minimal impact scope and cost.

Currently, some banking and financial institutions have started to practice. For example, in 2023, China Construction Bank built an enterprise-level privacy computing platform - a multi-party data security sharing platform. In addition, CCB and fin-tech companies such as Meitnerium are jointly exploring data sharing models through federated modeling, anonymous queries, and secure computing. Financial regulatory agencies should require participating banking and financial institutions to establish a comprehensive data management platform, incorporating all data involved in the cooperation between banks and fin-tech enterprises into the management scope of the bank's data assets. The Technology Supervision Department of the State Administration of Financial Regulation should establish an automated data collection system to achieve full process supervision of cooperation through system embedding and other methods, ensuring that the operation of data complies with legal regulations.

#### **4.3. Real-time acquisition of regulatory data to establish a hierarchical regulatory system for bank enterprise cooperation**

In order to prevent the occurrence of moral hazard in fin-tech companies, financial regulatory authorities should upgrade and iterate their regulatory measures, actively introduce regulatory technology to improve the technological and intelligent level of regulation. The financial data collection system should be connected to the data systems of banking and financial institutions, as well as fin-tech enterprises. The Technology Supervision Department of the Financial Supervision Bureau will complete regulatory reports and compliance management through tools such as data visualization analysis. In the technology-driven regulatory model, the regulatory subject and object establish a data sharing mechanism, forming a tripartite data exchange system through data sharing among regulatory agencies, banking and financial institutions, and fin-tech enterprises. This transforms the traditional single regulatory model into a multi-party governance supported by technology, promoting regulatory agencies to follow up on the dynamic development of bank enterprise cooperation in real time. At the same time, regulatory agencies use automated and technological means such as data mining, analysis, and processing to manage financial data related to bank enterprise cooperation. They utilize the intelligent judgment function of emerging technologies to lock in risks and greatly improve the automation level of supervision through intelligent dynamic regulatory mechanisms, thereby enhancing the efficiency of financial supervision. Empowering financial regulation through technology, accurately tracking data from regulatory partners, and continuously improving the technological level of financial regulation.

In order to prevent the occurrence of systemic risks, a hierarchical regulatory system for bank enterprise cooperation is established based on the cooperation partners, cooperation content, and number of partners of fin-tech enterprises. Because some fin-tech companies are currently not included in the scope of financial regulation,

the main body responsible for fulfilling reporting obligations is the banking and financial institutions. This requires banking and financial institutions to investigate the relevant backgrounds of cooperating fin-tech companies and effectively fulfill their substantive review responsibilities. The State Administration of Financial Supervision and Administration has established a hierarchical supervision system based on the cooperation situation of fin-tech enterprises, focusing on tracking the financial data of fin-tech enterprises and conducting comprehensive supervision of business cooperation to ensure the comprehensiveness and timeliness of financial supervision.

## 5. Conclusion

To summarize, when banks and fintech companies engage in financial cooperation, they should strengthen supervision in various aspects such as data transmission, data use, and data protection during the cooperation process, maintain financial data security, and promote the circulation of financial data on the basis of financial supervision.

## Disclosure statement

The author declares no conflict of interest.

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# Economic and Cultural Revitalization in the Construction of New Rural Areas in Jiangsu Province

Rui Zhang\*

Shanghai ACABridge College, Shanghai 201306, China

*\*Author to whom correspondence should be addressed.*

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**Abstract:** Jiangsu, a Chinese province that actively pursues both economic progress and rural cultural protection within China's new Rural Revitalization Strategy, is both a testbed of social engineering regarding the establishment of modernization and the fusion of economic development and cultural heritage preservation. This work seeks to theoretically examine the dynamics of rural Chinese social, economic, and cultural structures from both macro and micro levels with a micro-level case study, to better understand what is the economic productivity and cultural revival in contemporary China, and more importantly, why they may not have optimal potential. Data came from 3-week trips to Huishan Ancient Town, Hongcun village in Huizhou, Changxing county in Anhui, and Zhouzhuang village in Suzhou, as well as from 18+ primary and secondary literature surveys and country-level data such as annual China's No.1 Central Document policies. Structural problems (lack of policy enforcement or implementation regarding cultural protection, improper waste and pollution, loose control of building) and well-functioning models of collaboration (relying upon cultures as engines to drive the local economy) of rural areas in China's urban economy are highlighted here for proper understanding and examination of data sets. Case analysis through quantitative interpretations of policy measures, cross-sectoral model collaborations, and sustainability factors' impacts are applied in an integrated form to a novel structure of rural governance (bottom-up community innovation, technology-enhanced data capital, monetary reform regarding cultural heritage, adaptive policy design for optimal human well-being) that pushes for rural development in China's contemporary background. Keywords: Rural revitalization; Cultural heritage; Industrial integration; Sustainable development; Community governance

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## 1. Introduction

An interest in the topic starts from an academic pursuit in economic frameworks and from the first-hand experience regarding the rural-urban gap in contemporary China. Growing up with the textbook neo-classical growth model, regional economic development theory and other economic frameworks, textbooks often

overlooked two main facts that happened in rural China where this study is focused on: the textbook models fail to take into consideration the phenomenon of China's vast rural countryside, which is both sustained by years-old cultural legacy and shaped by swift urbanization; the economic development speed in Jiangsu Province and the vast rural countryside is highly unbalanced, where, although many of the cities and districts, like Suzhou, are ranked among the richest cities in China, 23% of all the local towns in rural areas still depend predominantly upon agricultural production. The announcement of Jiangsu Province as a "Pilot zone for Rural Revitalization" by the Central Committee of the Chinese Communist Party in 2021 also triggered my interest about the approach Jiangsu could possibly take while reviving the economy that would not abandon or vacillate on the 1268 local "traditional villages" currently registered, upon which our society built its historical heritage over centuries.

Most significantly, a 2023 World Bank study listed Jiangsu countryside's three problems as 15% annual urban youth emigration, 38% old buildings in danger, and 27% urban-rural per capita income gap <sup>[1]</sup>. The gap suggests the necessity of balancing local economic development with preservation of culture heritage. The provincial rural GDP growth is annually lower by 3.2 percentage points than urban growth since 2018, and the cultural heritage protection fund takes up 1.8% of the province's infrastructure fund, which makes preserving such cultural heritage a huge difficulty to overcome. Thus, it is decided to pursue potential models in which cultural heritage itself is an "engine of resilience" in local economies and gain a more hands-on experience with NGOs doing village development work as well by applying for internship positions through NGOs and getting a rough scan of my village in hometown through preliminary investigation.

## **2. Identified challenges in new rural development**

Through field research in six counties in Jiangsu Province, three interrelated problems that obstruct whole village development is found, all of which are supported by case studies and granular data. There is inadequate garbage and solid waste management, and poor classification at that. Waste sorting implementation covers a mere 35 percent of villages in Yixing by 2024, below even the province's goal of 70 percent <sup>[2]</sup>. A case study of the Wuxi Binhu area revealed that 68 percent of residents threw their household kitchen garbage and recyclable garbage together in loose piles in June 2024, while 42 percent of them used landfills without proper operating permission. The reasons go to more fundamentals: inadequate infrastructure with a garbage recycling station covering on average twelve villages and leaving citizens need to walk 8-15 miles to dispose of; literacy level limitation with 43% of rural population with primary education or less, and governance fragmentation, that three government departments at the village level were in charge of the whole business of waste handling, creating confusion in policy and blame game. It is found in a 2024 survey of Nanjing University that villages with a self-organized community waste committee cut illegal garbage dump by 57% compared to 19% of the managed villages by government and a Zhangjiajiang government sponsored a pilot project on using colored-bin household waste trashcan and a QR code instruction reduced violation rate from 22% to 61% in six months <sup>[3]</sup>.



**Figure 1.** Garbage disposal map of the village



**Figure 2.** Demonstration effect diagram of the waste classification guidance using color-coded trash cans

Lack of regulation endangers historic cohesion and structural integrity as 58% of historic buildings in Jiangsu province will be lost or changed by 2024 <sup>[4]</sup>. With satellite imagery data, it was found that 62% of newly constructed peasant houses in Suzhou Taihu Lake area has breached the architectural norms prescribed for the “Jiangnan Water Towns”, transforming its original roofing (pitched tiles and grey brick facades) into a standard uniform concrete style <sup>[5, 6]</sup>. Regulatory loopholes account for part of the non-compliance (i.e. 71% of all unreported buildings); rural townships handle residential building permission procedures and they employ at the rate of just 2.3 licensed planners per 10,000 people. Economic gain seems to be an even stronger motive; concrete houses are cheaper by as much as 38% when compared with traditional brick-and-wood houses. The implications could be considered a serious safety concern: 23% of unreported buildings in Changzhou failed the seismicity tests; 3% of listed building were measured before they were built. The case of Kunshan demonstrated that when providing a 20% of the construction price as an incentive for building with historical materials, from the period of three years 14% of such structures went up to 49%. The project was funded by a tourism tax that resulted in ¥12 million revenue but also saved 230 historical structures.

Even though Jiangsu have reduced the amount of absolute poverty to 0.3% in rural region by 2023, 61% rural households engaged in monocropping of rice farming and their profit margin varies by 42% each year <sup>[7]</sup>. Strawberry Cooperative, founded by the government in Lianyungang, ran out of business within 3 years due to lacking in cold-storage (12% of rural enterprises have cold-storage), and the prevalence of internet-based sales of products through the e-commerce platform. 72% of laborers (aged 18-35) in rural regions travel out of the province for their job, 40 leaving behind 29% labor shortage, and 31% less crop diversification from 2018-2023; according to the report of Jiangsu Agricultural University, the villages with a diversified economy have an income resilience of 3.2 times the amount for the same village when there is a pandemic (such as 2022 Omicron Virus outbreak) while Taizhou pilot implemented diversifying sector integrating aquaculture with nature and ecology tourism helped their farmers increase their income by 170% (a year in the last five years).

### 3. Theoretical framework and research methods

The above examples for case studies are based on the economic theory as well as theories from cultural studies and sustainable development, which laid a sound theoretical foundation and prerequisite to address Jiangsu’s rural



revitalization. Schultz (1961) is known for Human Capital Theory, which focuses on the relationship between education level/skills training and production in the countryside. In Jiangsu, such theory can be empirically tested by the connection between countryside's education level and diversified income—villages with vocational training school in Changxing County had 41% higher per capita than in villages without training school which exhibits the transformation from human capital to the economic expansion, and it is also confirmed by the empirical estimate of Li (2023) that an increase of one percentage point in countryside's education level leads to 2.1 percentage points increase in non-agricultural income.

Heritage is instrumentally quantified via Bourdieu's (1986) notion of Cultural Capital in the theoretical model applied to Huishan Ancient Town. In this context, Cultural Capital is taken as a bundle of tangible heritage (Ming-Qing buildings), intangible activities (bamboo weaving), and socio-cultural knowledge. The model estimates cultural capital (mth Cultural Capital) to account for 18% of local economy (mth GDP) while each 1 unit increase of cultural capital is associated to an increase of 1.8% in tourist revenue <sup>[8]</sup>. Thus, the theoretical lens offered here disentangles how local heritage preservation—which is traditionally regarded as a cultural business—becomes an economic tool to realize local rural revitalization efforts under the provincial plan to monetize culture capital.

According to the classic theoretical proposition put forward by Elkington's (1997) Triple Bottom Line (TBL) framework, the true performance analysis requires a holistic integration of the impacts in economic development, social development, and environmental preservation <sup>[9]</sup>. In Hongcun Village, restoring the water system notably not only achieved clean water quality (63% improvement) (environmental), attracted more tourism money (up 120%) (economic), but also resulted in greater social harmony in community relationships (76% of residents said that they became closer after the project) (social) <sup>[10]</sup>. The TBL framework also paves the way for us to more in-depth discuss the three dimensions involved in the success of a rural model in Jiangsu beyond the simple GDP measuring stick to human inclusion.

Alongside these, North's (1990) New Institutional Economics (NIE) theory is used to interpret how formal and informal institutions influence village-level developmental impacts. For Hongcun, NIE is deployed to demonstrate how the informal norms embedded in communal covenants brought about a remarkable 85% policy compliance compared to a 76% state policy compliance; in fact the latter is surpassed as well since these informal norms were integrated into the collective decision-making structure within the village (i.e., public goods responsibility) <sup>[11]</sup>. NIE thus demonstrates how institutions (regardless of how strict or non-binding) must be 'flexible enough' for their benefits to be effective, as in Huishan's Public Private Partnership (PPP) model which employed a range of formal policies (such as municipal flood damage insurance, road access levies and crop damage subsidies), and a combination of informal stakeholder alliances that lowered government fiscal costs by 40% (Chen and Van Schendel, 2015).

This study adopted a mixed-method strategy to gain an integrated understanding of the research data. Over sixteen days at 5 counties/ancient towns, the researchers conducted 45 non-directive interviews with stakeholders of different profiles, including local government officials, local residents, artisans, cooperative farmers, and heritage professionals. A combination of participant observation (28 hours of field observation in community assembly, handicraft workshops, and agriculture cooperatives), photographic recording of traditional buildings and rural construction project, enables the triangulation of the qualitative and quantitative analysis of the data presented here with governmental statistical references (2015–2024 Jiangsu Bureau of Statistics rural development data report), datasets from World Bank China Rural Revitalization Database, and the secondary literature: 18+ in Chinese and English academic published cases covering aspects of rural house, waste management, cultural

tourism.

Through GIS (ArcMap), a total of 5,200+ buildings in rural communities were located, and the spatial patterns of building violations were assessed, while the online Nvivo software was utilized to deconstruct main concepts from an interview with local residents as well as form a logical argument for the residents' difficulties in doing waste sorting, and perceptions on the conservation of traditional buildings. B/C analysis was undertaken to evaluate in financial terms a 20-year (year zero represents as year 2017) estimate of difference in value between complying with the traditional building standards and that of modern constructions. These comparisons prove that, for the small town such as Zhouzhuang, compliant building complies with the 2.3x higher value from time-series perspective. The multi-dimensional methods maintain that theory should not only be put into application, but also in line with concrete cases and tested within reality, and ultimately to provide stronger basis for policy advice.

#### 4. Case studies and best practices in rural revitalization

Quantitative analysis of four effective models in field investigations shows that the Huishan Ancient Town Government's heritage zone is operated by the government and it takes a multi-level fund plan from 2015 to 2023 with a size of ¥1.2 billion (¥720 million as the governmental subsidies and ¥480 million as private investors), which is assisted by a heritage tax of the tourism revenue valued at ¥120 million by 2023. There are twelve "craft studio" that supplies the craftsman with free workshops, 30% of supplies subsidy, and marketing, it formed new businesses by 89, and crafts sales increased by 210% <sup>[12]</sup>. The method of community buy-ins is allocating 15% of the revenue from tourism for the welfare of the residents, hiring the residents with priority, hold a heritage culture festival every year, tourism number increased from 800,000 people to 2.3 million people, and the average income increased to 185%.



**Figure 3.** Huishan Ancient Town building layout map



**Figure 4.** Hongcun Village overall layout map

Hongcun Village, a community-driven cultural ecology management with a level 2 water system management hierarchy: UNESCO, Community rota with 85% of the families involved in the water management. The architectural covenant system demands approvals and government grants (40% for traditional materials) and tax deduction, with an approval rate of 92%, and 76% of resident satisfaction levels; art colleges build partnerships



that attract 15 thousand visiting students every year, for ¥ 3.6 M, and the “living museum” concept pays local people to practice traditional activities to generate local awareness to prevent the youth from leaving: a 22% reduction in outmigration <sup>[13]</sup>.



**Figure 5.** Students sketching in Hongcun Village



**Figure 6.** Tourists sketching Hongcun's architecture

Changxing County's phase-out of coal produces: closure of 47 mines (2016-2020), afforestation of 12,000 hectares, and cleanup of ¥2.8 billion, resulting in a 41% reduction in emissions and 12,000 new jobs. Eighty-nine farmer cooperatives utilize drones, blockchain, and solar-powered irrigation to boost organic tea yield by 35% and receive the EU certification <sup>[14]</sup>. Agritourism integration fosters 52 farms' stays, increasing the time spent by the average visitor from 1.2 days to 3.5 days, with revenue-sharing distributing a percentage of the profit of 30% to farmers. Achieving a per capita income of ¥48,000 and eliminating 17% percent of the rural–urban income gaps.

Fourth, Zhouzhuang (added) achieves rural-urban integration by cultural tourism investment of ¥800 million on a “rural-urban tourism corridor” joining 15 crafts villages with 8 agricultural parks. For example, Suzhou embroidery training centers have trained 2,000+ rural women, which makes the products on e-commerce gain 120% of value, and 10% from the tourism revenue fund is used for rural infrastructure to provide 6,000 jobs and increase per capita income of the surrounding village by 150%, meanwhile preserving 312 traditional arts and crafts <sup>[15, 16]</sup>.

Theoretical aggregation finds 4 general laws: (1) Institutional adaptability (the Huishan PPP cuts the government's financial burden by 40% ); (2) Social competence empowerment (the Hongcun villagers achieve 85% policy compliance rate); (3) Combination of IT (in Changxing, labor productivity improves 2.7-fold), and; (4) Regional connectivity (in Zhouzhuang, incomes increase by 1.5-2 times). By 2024, a meta-study finds from the World Bank that diversified villages have 3.7-fold economic adaptability and a 62-percentage point increase in the popular satisfaction level.

## 5. Vision for future rural management

### 5.1. Community-driven economic ecosystems

The goal is to “empower local communities as participants in rural revitalization on an equal footing,” in accordance with the call for sustained rural development through farmers' cooperation, which, building on the

farmer cooperatives developed in Changxing (Jiangsu) (a township at county level, or Xiangli), aims at multiplying them throughout all 80% of rural townships by 2028; by improving logistics access centres to facilitate logistics in these areas and reduce transport expenses by 25%, through the creation of a “Jiangsu Rural Premium” brand of marketing campaigns sharing cooperatives, and the same distribution model as that applied by agritourism in Changxing’s cooperatives (40% of revenues profit, 30% remitted in profit-sharing model to farmers) and 20% reinvested in infrastructure.

“Rural Innovation Fellowships” would enable a return of ¥ 100,000 grants to youth who have returned home, and “experienced entrepreneur mentors”. “Youth Innovator” training programs would include courses on digital promotion and organic farming, and cultural design for the purpose of reducing youth outmigration from 72 to 36 percent in five years, based on successful innovation in Hongcun that decreased youth outmigration from heritage-related fields from 22% to 0.18% (Nien). Small-scale agricultural “innovation hubs”, based on the innovative “smart agriculture cooperative” model in Changxing, would aim to empower small-scale farmers through technology and market information.

## **5.2. Tech-enabled sustainable development**

Digital and renewable energy will be priorities in the transformation of the villages’ economic structure without damaging the ecological environment. To emulate the QR-code-based sorting rate of 80% of Zhangjiagang’s waste, Shanghai aims to build “intelligent garbage collection boxes” across the province equipped with Internet of Things (IoT) sensors on garbage cans to notify the waste collection when the cans reach 80% full, and intelligent garbage-collection route with the help of artificial intelligence by 2028. The deployment of blockchain technology for 60% of all agricultural products by 2028 will help people know exactly where their food originated from by scanning the product’s code when visiting Changxing (a city famous for its tea supply chain).

Public grants of half of the construction investment would be made on solar pumping devices for irrigation and low-carbon houses. Emission credits of emissions mitigation projects of rural areas would be sold to relevant departments through carbon trading platforms and set the goal to mitigate 40% rural carbon emissions by the year 2035 to meet the goal of Jiangsu Province. Drones of agricultural science and technology that achieved the green development would be widely developed and popularized, in which 70% of the rural farmland has used drone monitoring to monitor the cultivation status, the workload of farmers is expected to decline by up to 60% and annual growth rates of crops are projected to increase by 35%. Development of drones of agricultural science and technology. Through the use of big data, big cloud, intelligent equipment, and mobile internet, medical diagnosis and teaching and learning through cloud networks, bridge the gap between urban-rural service quality and shorten the distance between the front and back lines.

## **5.3. Inclusive governance and adaptive management**

Participation and responsiveness should be cornerstones of good governance. The village assembly would be reformed to guarantee female and youth representation (i.e., 50%) by proportional representation election to guarantee that the collective voice of residents would be heard. Additionally, there will be yearly “town-hall” events at which residents (now available digitally) will allow the local government to do actual policy-making. Finally, the adoption of the (open water management committees) of the village is based upon active participation models, which achieve 85% levels of policy adoption compared to levels of [top-down management systems].

The policies would be implemented through the creation of a “Rural Vitality Index” to measure, quarter by

quarter, the progress in economic, social-cultural, and environmental improvement towards each specific objective (such as jobs, income per capita, educational attainment, rates of preservation of cultural heritage, and carbon footprint of urban systems). We envision a real-time scorecard policy review: every quarter, the score would reflect how local communities were faring on achieving the economic, social, and environmental objectives detailed in the plan; the government or the government-supported initiative would then redistribute the available funds through a variety of programmes (such as the 2016 artisans' incubation scheme in Huishan, Yunnan province). For example, if the "heritage preservation" score seemed to have stagnated, policy funding would be switched to cultural heritage workshops in order to prevent further decay of the living heritage of a particular area, for instance. To aggregate local level information, real-time scorecards collected from citizens on a 1–10 scale where they rate their rating of the government policy. This creates a sense of ownership among residents of the policy.

These principles are, of course, neither blueprints nor rigid plans, but flexible to the needs of specific locations and global shifts in context. The rural development that Jiangsu needs and can become is thus a flexible template based on combining the heritage zoning of Huishan and the resident management of Hongcun with the technological approach of Changxing and the urban-rural connection of Zhouzhuang, in other words, a renewal of rural areas so that tradition and modernity support and complement each other.

## 6. Conclusion

Drawing from the synthesis of case studies and theory and grounded in context, as a rural practitioner living in Jiangsu and eager to boost economic and cultural vitality, achieving the following four strategies (Strategic Pillars) which could facilitate Jiangsu rural revitalization in formulating its future rural development framework to convert and integrate the local rural revitalization efforts as a successful mode of economic growth sustainable cultural integration.

In holistic planning with cultural anchors, the primary principle is integrated zoning between protecting the heritage, ecological agri-tourism, and tourism. Like the successful heritage zoning at Huishan, advocate tripartite land zoning of 20% heritage protection zones (property tax incentive of a 15% discount to current owners of each heritage structure to keep maintaining the Chinese traditional style), 50% ecologically agri-cultural zones (¥5, 000 per hectare land subsidy to promote green technologies and organic food production, as has recently been pushed in Changxing's post-industrial rejuvenation), and 30% tourism corridor zone (strict zoning on aesthetic regulations to avoid making tourism sector becoming over-commercialized, as demonstrated by the new and integrated rural craft village of Zhouzhuang and the expansive integration of other nearby traditional villages into the city tourism network).

Next, there will be incentives to develop the cultural value chain, promoting collaboration between more than 500 craftsmen and e-commerce as well as overseas markets, forming a "Jiangnan Crafts Alliance." (Inspiration was drawn from Hui Shan's artisan incubation project.) Additionally, the "Jiangnan Heritage Bank" (inspiration come from Hui Shan's "PPP" Project) will be established to attract funding for restoration and repair through public donations, philanthropic donations, and tourism taxes. (For example, the Jiangnan Heritage Bank would establish the same kind of leasing relations as Zhouzhuang's "Heritage Architecture Bank," which allows families to lease their own traditional house to the Heritage Trust, from whom the residents receive an income stream while a trustworthy contractor maintains and operates the historic property.) In addition, there will be promotions to export cultural products by enhancing 30 percent, by the year 2030.

## Disclosure statement

The author declares no conflict of interest.

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# Exploring Optimization Strategies for Island Power Grid Line Layout Oriented Towards Large-Scale Distributed Renewable Energy Integration

Zhenhuan Song, Wenxin Liu

Three Gorges University, Yichang 443000, Hubei, China

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**Abstract:** The construction of island power grids is a systematic engineering task. To ensure the safe operation of power grid systems, optimizing the line layout of island power grids is crucial. Especially in the current context of large-scale distributed renewable energy integration into the power grid, conventional island power grid line layouts can no longer meet actual demands. It is necessary to combine the operational characteristics of island power systems and historical load data to perform load forecasting, thereby generating power grid line layout paths. This article focuses on large-scale distributed renewable energy integration, summarizing optimization strategies for island power grid line layouts, and providing a solid guarantee for the safe and stable operation of island power systems.

**Keywords:** Island power grid; Line layout; Optimization strategy; Distributed renewable energy; Large-scale

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## 1. Introduction

Renewable energy technologies continue to evolve, and the cost of renewable energy generation has been significantly reduced. Accelerating large-scale and distributed renewable energy integration into island power grids has become an inevitable trend, bringing greater challenges to island power grid line planning. At present, domestic island power grid line planning has achieved certain results. However, with the steady integration of large-scale distributed renewable energy, the limitations of traditional methods based on historical experience and expert judgment for planning line layouts have become increasingly evident. It is difficult to accurately grasp the power grid's operational status after renewable energy integration, which seriously threatens the stability and safety of power grid operations. How to further optimize and improve has become a top priority.

### 1.1. Island power load forecasting

Due to their geographical specificity, island power grids belong to independent or semi-independent power systems. They have strong load fluctuations, small power supply radii, and the advantage of high renewable energy



utilization rates. In the future, with the integration of large-scale distributed renewable energy, island power grids will face many new challenges in supply and demand balance. As a fundamental aspect of power grid planning, power load forecasting essentially collects historical data and information for multi-dimensional analysis to predict future electricity demand over a period of time. This provides support for subsequent renewable energy capacity allocation, line regulation, and power grid topology design <sup>[1]</sup>.

The power load on island grids includes commercial, residential, public facility, and industrial electricity consumption. Some islands are primarily focused on tourism, and during the peak season, a large influx of tourists increases the demand for electricity on the island. During the low season, the electrical load on the island decreases, resulting in significant seasonal fluctuations in power load. Other islands are mainly focused on industries such as fisheries processing, where production electricity consumption exhibits intermittent and cyclical characteristics, greatly increasing the complexity of the island's power load.

By collecting power load data from different regions of the island and using normalization methods, data cleaning and conversion are achieved using the following formula:

$$x_{norm} = \frac{x - x_{min}}{x_{max} - x_{min}} \quad (1)$$

In the formula,  $x_{norm}$ ,  $x_{max}$ ,  $x_{min}$ ,  $x$  represent normalized data, the maximum value of the dataset, the minimum value, and the original load data, respectively. Data normalization emphasizes scaling features to the same numerical range. Combining the operating characteristics of the island's power system and forecasting goals, regression prediction methods are used to forecast the island's power load, using the following formula:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \varepsilon \quad (2)$$

In the formula,  $\varepsilon$ ,  $\beta_i$ ,  $Y$ ,  $X_i$  represent the error value, regression coefficient, predicted power load of the island, and influencing factors, respectively. Based on the above formulas, the power load on the island can be accurately predicted, providing a reliable data basis for subsequent power system planning and operation on the island.

## 2. Analysis of large-scale distributed renewable energy access points

### 2.1. Planning objectives for access points

In the planning and design of island power grid lines, it is necessary to consider the selection of large-scale distributed renewable energy access points. Whether the access point selection is reasonable relates to the stability and reliability of the power system operation. Specific planning needs to meet the following objectives: (1) Maximize renewable energy consumption: Placing access points in the crossover area between renewable energy-rich areas and load-intensive areas can effectively avoid excessive line losses due to long transmission distances; (2) Improve grid resilience: Adopting multi-point decentralized access to the island grid and establishing an "N-1" redundant structure can effectively avoid cascading failures caused by single-point failures, minimizing the risk of large-scale power outages <sup>[2]</sup>; (3) Optimize economy: Comprehensive consideration of renewable energy equipment investment, lifecycle operation and maintenance costs, and line renovation costs.

### 2.2. Access potential evaluation

The large-scale distributed access of new energy on islands requires a full understanding of the spatial distribution characteristics of resources in the region, as shown in **Table 1**.

**Table 1.** Spatial distribution characteristics of island resources

New energy type	Key Metrics	Data acquisition method
Photovoltaics	Inclined surface irradiance and shadow occlusion	Satellite remote sensing + drone aerial photography modeling
Wind power	Annual average wind speed at 50m height	LIDAR wind tower + meteorological reanalysis data
Wave energy	Significant wave height, energy flux density	Ocean buoy monitoring + numerical simulation

A two-tier evaluation framework is adopted to establish a quantitative model for assessing the potential of large-scale distributed new energy access on islands. The formula for calculating the maximum technical development capacity of photovoltaic systems is as follows:

$$P_{\max}^{PV} = \eta \bullet A_{\text{roof}} \bullet G_{\text{tilt}} \bullet PR \quad (3)$$

In the formula,  $\eta$  represents inverter efficiency, PR denotes the performance ratio,  $P_{\max}^{PV}$  stands for the maximum technical development capacity of the photovoltaic system,  $A_{\text{roof}}$  represents the actual available roof area,  $G_{\text{tilt}}$  signifies irradiance on the inclined surface, and PR is the performance ratio.

In addition, a comprehensive evaluation index system is established to comprehensively evaluate the feasibility of access point selection from the dimensions of energy matching degree, ecological sensitivity, return on investment, and fault ride-through capability<sup>[3]</sup>. Based on the modified NSGA-II algorithm for the access point location model, the objective function minimizes ( $f_1$  represents the total investment cost of lines,  $f_2$  denotes the expected grid loss, and  $f_3$  signifies the voltage fluctuation variance). An adaptive penalty function is employed for power flow limit constraints. The specific formulas are as follows:

(1) Economic objective function formula:

$$f_1 = \sum_{k \in \Omega L} c_k^{\text{line}} \cdot l_k \cdot x_k + \sum_{i \in \Omega DG} c_i^{DG} \cdot P_i^{\max} \cdot y_i \quad (4)$$

In the formula,  $x_k$  and  $y_i$  indicate whether line  $k$  is constructed and whether node  $i$  is connected to new energy, respectively.  $c_k^{\text{line}}$ ,  $l_k$ , and  $c_i^{DG}$  represent the unit length line cost, line length, and new energy unit capacity cost, respectively.

(2) Power stability objective function formula:

$$f_3 = \frac{1}{N} \sum_{i \in \Omega N} \left[ \frac{1}{T} \sum_{t \in T} (V_i(t) - \bar{V}_i)^2 \right] \quad (5)$$

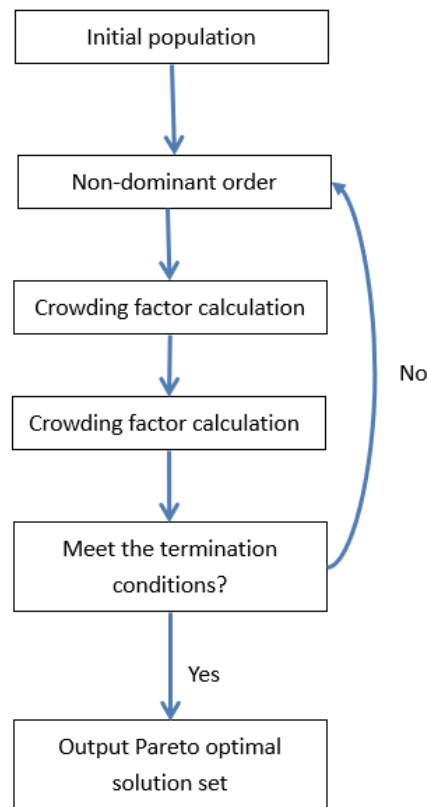
In the formula,  $\bar{V}_i$  represents the rated voltage, and N denotes the number of nodes.

(3) Power flow formula:

$$\begin{cases} P_{ij} = P_j + r_{ij} \frac{P_{ij}^2 + Q_{ij}^2}{V_i^2} + \sum k: j \rightarrow k P_{jk} \\ Q_{ij} = Q_j + x_{ij} \frac{P_{ij}^2 + Q_{ij}^2}{V_i^2} + \sum k: j \rightarrow k Q_{jk} \\ V_j^2 = V_i^2 - 2(r_{ij}P_{ij} + x_{ij}Q_{ij}) + (r_{ij}^2 + x_{ij}^2) \frac{P_{ij}^2 + Q_{ij}^2}{V_i^2} \end{cases} \quad (6)$$

\*Applicable to all lines  $i \rightarrow j$ .

The specific algorithm flow is shown in **Figure 1**.



**Figure 1.** Algorithm flow

After distributed new energy is integrated into the island power grid, it is connected to the island distribution network in a distributed manner, with real-time monitoring and adjustment, so that the new energy generation facilities can be smoothly integrated into the grid, thereby improving the operational stability of the island power grid.

### 3. Optimization strategy for large-scale distributed new energy access to island power grid line layout

Based on selecting appropriate large-scale distributed new energy access points, it is necessary to plan the island power grid line layout reasonably to achieve full integration of large-scale new energy <sup>[4]</sup>.

#### 3.1. Optimization of line layout objectives and constraint systems

The optimization of island power grid line layout should tightly focus on the triple objectives of safety, economy, and low carbon emissions. A multi-objective optimization model is established as follows:

(1) Economic objective

$$F_1 = \sum_{i \in \Omega L} (C_{line}^i \cdot L_i \cdot \delta_i) + \sum_{i \in \Omega DG} C_{DG}^i \cdot P_{DG}^{i, \max} \quad (7)$$

In the formula,  $\delta_i$  ranges from 0 to 1, indicating whether construction is carried out;  $C_{line}^i$ ,  $L_i$ , and  $C_{DG}^i$  represent the unit length line cost, line length, and new energy unit capacity cost, respectively.

(2) Safety objective

$$F_2 = \sum_{t=1}^T \sum_{k \in \Omega L} I_k^2(t) \cdot R_k \cdot \Delta t \quad (8)$$

In the formula,  $I_k(t)$  and  $R_k$  denote the current and resistance of line  $k$  during time period  $t$ , respectively.

(3) Low-carbon objective

$$F_3 = \frac{\sum_{t=1}^T \sum_{j \in \Omega D} P_D^j(t) \cdot \Delta t}{\sum_{t=1}^T P_{load}(t) \cdot \Delta t} \times 100\% \quad (9)$$

Using the weighted sum method, the multi-objective problem can be transformed into a single-objective optimization analysis:

$$\min \left( \lambda_1 \frac{F_1}{F_1^{base}} + \lambda_2 \frac{F_2}{F_2^{base}} - \lambda_3 \frac{F_3}{F_3^{base}} \right) \quad (10)$$

In the formula,  $F_i^{base}$  it represents the target value of the baseline scenario.

Based on optimizing the line layout objectives, corresponding constraints should be determined to ensure the feasibility and practicality of the line layout optimization plan. Specific analyses can be conducted from perspectives such as topological structure constraints, line capacity, environmental, and engineering constraints.

(1) Electrical safety constraints:

$$\text{Power Flow Equation: } P_G - P_L = V \sum V (G \cos \theta + B \sin) \theta \quad (11)$$

(2) Topological constraints:

$$\text{Radial Operation Equation: } N_{branch} = N_{node} - 1 \quad (12)$$

The island power grid operates in a radial configuration:

$$N_{branch} = N_{node} - N_{source} \quad (13)$$

Formula  $N_{source}$  represents the number of main power source nodes.

The line capacity refers to the maximum current value that a power grid line can carry under normal operating conditions. By constraining the line capacity, it can be ensured that the later line current value does not exceed the rated capacity, avoiding overload failures. In each line  $l_i$ , the flowing current  $I_i$  should not exceed the maximum allowed current.

In terms of environmental and engineering constraints, it is required that the power grid line layout maintains a buffer distance of not less than 500m from ecological protection areas such as coral reefs and mangrove forests; in coastal areas, the line salt fog corrosion level is not less than C4, meeting the requirements of ISO 9223 standard; if the slope of the construction area exceeds 30°, overhead construction of lines is not allowed<sup>[5]</sup>.

### 3.2. Establishment of a multi-agent collaborative optimization framework

Focusing on a two-tier and multi-agent optimization framework. The upper planning layer includes government entities and power grid companies. The former sets the minimum renewable energy penetration rate ( $\geq 40\%$ ) and carbon emission quotas; adheres to the goal of maximizing return on investment and prepares reasonable main grid framework plans. The lower operational layer includes distributed power clusters and load aggregators. The former uses consensus algorithms to draw output curves, while the latter adjusts demand-side response based on electricity price signals <sup>[6]</sup>.

### 3.3. Line impedance matching and dynamic reconstruction technology

Calculating line capacity based on the distribution of renewable energy access points. Some offshore wind power transmission lines are suitable for choosing cross-linked polyethylene insulated cables with lap joints, which have a 1.8 times higher current carrying capacity compared to conventional cables; in areas with severe salt fog corrosion, tin-plated copper core wires are suitable, and anticorrosive additives are added to the insulation layer <sup>[7]</sup>. Combining the fluctuation of renewable energy output, the line is equipped with adjustable reactors and static var generators. Once the peak photovoltaic output causes abnormal voltage rise in the line, the static var generator can absorb excess reactive power; voltage fluctuations caused by wind power output fluctuations can be dynamically adjusted by reactors to adjust line impedance. The quantitative relationship formula between line parameters and renewable energy capacity is as follows:

$$Z_{line} = \frac{R + jX}{S_{DG}^{max}} \leq K_{stab} \quad (14)$$

In the formula,  $K_{stab}$  represents the system stability coefficient, and the impedance optimization is achieved by reasonably adjusting the wire cross-sectional area. Additionally, combining the extreme climate that island lines may encounter, the adaptability design of the lines is optimized. In some areas frequented by typhoons, the line is suitable for choosing a structure combining tension towers with optical cable composite overhead ground wires. The towers can withstand wind speed impacts of 45m/s, and anti-pollution flashover composite insulators are selected; waterproof and sealed structures are used for high-humidity island cable joints, filled with silicone insulating materials to enhance the extreme climate adaptability of island power grid lines <sup>[8–10]</sup>. Even in case of abnormalities, different warning mechanisms can be triggered according to the level of emergencies, and a three-level trigger mechanism can be established for the power grid, as shown in **Table 2**.

**Table 2.** Three-level event trigger mechanism

Level	Type	Response action
Level 1	Typhoon Red Warning	Switch to islanding mode - energy storage priority
Level 2	Load surge >20%	Activate smart soft open point (SOP)
Level 3	Renewable generation forecast deviation >15%	Adjust OLTC tap position and implement reactive power compensation

### 3.4. Simulation verification

A certain island in the South China Sea has a total area of 58 km<sup>2</sup>, with a peak power load of 32 MW, installed new energy photovoltaic capacity of 18 MW, wind power capacity of 9 MW, and energy storage of 15 MWh. The



island mainly uses 10 kV overhead lines, with an average load rate of 78%.

The IEEE 34-node distribution system is adopted, which includes 33 lines and 34 nodes, with a rated voltage of 24.9 kV and a total load of 4.8 MW + 2.0 Mvar. Photovoltaic power stations are connected to nodes 6, 12, 18, 25, and 30, while a wind turbine is connected to node 29, increasing the new energy penetration rate to 45%. The impedance of coastal lines is increased by 20%, and the reactance of mountain lines is increased by 15%. Specific parameters are shown in **Table 3**.

**Table 3.** Key parameter table

Parameter category	Original value	Island adaptation value
Peak Total Load	4.8 MW	6.2 MW
Average Line R/X Ratio	1.2	1.5
Allowable Voltage Deviation	±5%	±10%
Short-Circuit Capacity	12 MVA	18 MVA

After optimizing the island’s power grid layout using the planning method described in this paper, the overall cost has been reduced from 87.6 million yuan to 72.3 million yuan. The annual average network loss rate has dropped from 6.8% to 4.1%, the new energy consumption rate has increased from 72.3% to 88.6%, and the fault recovery time has been reduced from 45 minutes to 19 minutes.

## 4. Conclusion

In summary, new energy generation has a small environmental impact and relatively clean generation methods. With continuous updates and upgrades in new energy generation technology, generation costs have significantly decreased. Therefore, promoting large-scale distributed new energy access to island power grid systems has become a major area of new energy application. However, due to the randomness and intermittency of new energy sources, certain hidden dangers are posed to the stable operation of island power grids. Island power grid systems should comprehensively consider the demand for new energy grid connection, coordinate the economy, safety, and low carbon emissions of the power grid, and optimize the layout of lines, thereby improving operational efficiency and creating more ideal economic benefits.

## Disclosure statement

The authors declare no conflict of interest.

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# Research on the Impact of the Independent Director System on the Independence of the Board of Directors

Yanhua Ge\*

Xi'an Jiaotong-Liverpool University, Suzhou 215123, China

*\*Author to whom correspondence should be addressed.*

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**Abstract:** In the context of China's rapidly evolving capital market, the proliferation of listed companies has been a salient phenomenon. The quality of corporate governance has emerged as a pivotal factor in determining the success or failure of these entities. Research by Balsmeier *et al.* (2022) indicates that the greater the independence of a listed company's board of directors, the higher its innovation output (both in terms of quantity and quality of patents)<sup>[1]</sup>. This finding suggests a strong correlation between the performance of a company and the independence of its board. The present study has selected listed companies on the A-share market of the Shanghai Stock Exchange in 2013 as the subjects of its research. A sample of 960 companies was initially obtained from the CSMAR database. Following a rigorous financial data screening, a final sample of 944 valid companies was retained for further analysis.

**Keywords:** Independent director system; Independence of the board of directors; Governance mechanisms

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## 1. Introduction

The Ordinary Least Squares (OLS) method is employed in order to construct econometric models. Key explanatory variables are progressively introduced into the baseline model, and empirical analysis is conducted using RStudio. The research findings indicate that the enhancement of the independent director system exerts a significant positive impact on the improvement of board independence, thus providing crucial empirical evidence for the enhancement of the governance mechanisms of listed companies in China.

## 2. Replication of selected article

### 2.1. Original background and model overview

In their study, the researchers primarily examined the relationships between corporate governance mechanisms

(such as supervisory boards, equity concentration, state ownership, etc.) and board characteristics, while also testing the applicability of Western theories (such as the “Efficient Board Hypothesis”) in the Chinese context. Their research revealed that eleven factors, including the size of the supervisory board, equity concentration, and state ownership, significantly influence a company’s board characteristics.

## 2.2. Data sources and processing

The data for the study was entirely sourced from CSMAR. In the course of the data screening process, a temporal selection was first conducted in order to ensure the representativeness of the data. Subsequently, companies with stock codes commencing with ‘6’ were filtered out in order to maintain sample uniformity. Finally, enterprise codes with missing data were removed to ensure the completeness of the sample.

However, during the subsequent data processing phase, it was discovered that there was a significant amount of missing data related to diversification in the database. Consequently, in the present replication process, the impact of diversification on board characteristics is not considered and it is excluded when constructing the model.

## 2.3. Reproduction results demonstration

In this replication operation, the results obtained based on the 2013 data exhibit partial discrepancies with those in the original paper. The following section presents a comparison and analysis of each table.

### 2.3.1. The results of Table 1

A comparison of the data in **Table 1** with the original data reveals that the proportion of independent directors has exceeded the original data by 4%.

**Table 1.** Descriptive statistics of independent directors

Variables	Obs.	Mean	Median	Std-dev	Min	Max	Skew	Kurtosis
Board size	944	2.21	2.2	0.21	1.61	2.94	0.17	1.39
Independence	944	0.37	0.33	0.06	0.25	0.67	1.98	4.86
Supervisory-board	944	4.06	3	1.51	1	13	1.76	4.5
Concentration	944	0.18	0.15	0.14	0	0.78	1.03	0.89
State share	944	0.05	0	0.14	0	0.92	3.08	9.24
Managerial ownership	944	0.02	0	0.08	0	0.67	5.02	26.56
CEO	944	0.14	0	0.34	0	1	2.1	2.41
Size	944	22.62	22.41	1.7	17.82	30.57	1.11	2.94
Leverage	944	0.54	0.55	0.21	0.05	1.15	-0.04	-0.65
Profitability	944	0.08	0.07	1.2	-20.74	23.74	4.66	275.02
Age	944	13.05	13	5.21	0	23	-0.59	-0.23
Firm value	944	1.42	0.94	1.88	0	25.7	5.72	50.21

The underlying cause of this discrepancy may be attributed to the strengthening of the institutional environment by the state. In 2001, China was the first nation to mandate that the proportion of independent directors in listed companies should account for one-third of the board of directors, thereby facilitating early development in this area. The gradual improvement of the “Corporate Governance Guidelines for Listed Companies” has resulted in the clarification of immunity clauses for independent directors who express dissenting opinions. Furthermore, the state has mandated that independent directors hold a majority ( $\geq 50\%$ ) in compensation committees (CSRC, 2018), thereby significantly propelling the establishment of the independent director system <sup>[2]</sup>.

Moreover, in comparison with the original data, China’s publicly listed companies experienced an increase in financial leverage of 5.47% in 2013, while the mean ROE demonstrated a substantial improvement of 18%. The data indicates that Chinese enterprises continue to operate with high debt ratios, with a concomitant improvement in profitability, albeit not yet at an outstanding level. This finding indicates that, while Chinese companies are demonstrating a consistent upward trajectory, their growth potential is constrained. This phenomenon may be ascribed to China’s response to the 2008 economic crisis, which encompassed the initiation of the “Four Trillion Plan” policy, resulting in economic expansion and a relaxation of credit conditions <sup>[3]</sup>. Furthermore, the decline in corporate income tax rates from 33% to 25% consequent to the 2008 economic crisis is also a potential contributing factor to this phenomenon <sup>[4]</sup>.

### 2.3.2. The results of Table 2

The data presented in **Table 2** largely corroborate the conclusions drawn in the article, suggesting that the diminishing marginal effect of reforms could be the possible cause of this phenomenon. The fundamental structure of this section was established during the pivotal reforms between 2001 and 2005, with subsequent policy adjustments primarily constituting marginal corrections rather than comprehensive revisions.

**Table 2.** Correlation matrix of independent matrix

	1	2	3	4	5	6	7	8	9	10	11	12
Board size	1											
Independence	-0.340***	1										
Supervisory-board	0.459***	-0.033	1									
Concentration	0.097**	0.076*	0.095**	1								
State share	0.100**	-0.024	0.091**	0.263***	1							
Managerial ownership	-0.066*	0.021	-0.099**	-0.078*	-0.081*	1						
CEO	-0.136***	0.055	-0.093**	-0.113***	-0.047	0.114***	1					
Size	0.408***	0.096**	0.412***	0.391***	0.114***	-0.048	-0.121***	1				
Leverage	0.154***	0.044	0.168***	0.008	-0.017	-0.084**	-0.043	0.364***	1			
Profitability	-0.087**	0.053	0.003	-0.021	-0.01	0.001	0.102**	-0.078*	0.021	1		
Age	-0.125***	-0.059	-0.083*	-0.257***	-0.097**	-0.338***	-0.058	-0.196***	0.099**	0.006	1	
Firm value	-0.173***	0.064	-0.175***	-0.197***	-0.019	0.028	0.127***	-0.520***	-0.208***	0.375***	0.083*	1

Note: \*  $P < 0.10$ , \*\*  $P < 0.05$ , \*\*\*  $P < 0.01$ .



### 2.3.3. The results of Table 3

As demonstrated in **Table 3**, the findings reveal an inconsistency with the original conclusion, attributable to the negligible differences observed in the grouping by managerial shareholding. This phenomenon may be attributed, at least in part, to the tendency of managerial power to impede the expansion of boards. However, it is important to note that further research is necessary to confirm this hypothesis and to refine the conclusions that can be drawn.

**Table 3.** Subsample test of board characteristics

Variable	Subsample 1	Subsample 2	t-Statistics
State ownership			
Board-size	2.194	2.263	-4.189*** (0.000)
Independence	0.37	0.373	-0.557 (0.578)
Managerial ownership			
Board-size	2.206	2.212	-0.442 (0.658)
Independence	0.372	0.37	0.561 (0.575)
Supervisory board			
Board-size	2.143	2.298	-11.662*** (0.000)
Independence	0.373	0.367	1.688 (0.092)
CEO			
Board-size	2.221	2.137	4.372*** (0.000)
Independence	0.37	0.379	-1.573 (0.118)
Concentration			
Board-size	2.192	2.226	-2.467* (0.014)
Independence	0.368	0.374	-1.600 (0.110)

Note: \*  $P < 0.10$ , \*\*\*  $P < 0.01$ .

### 2.3.4. The results of Table 4

Based on **Table 4**, the present study finds that the impact of managerial ownership on board size is insignificant, which contradicts the conclusions drawn in the article. It has been determined by research that two potential reasons for this phenomenon exist. The initial effect is the offsetting outcome resulting from the early (1999–2001) negative influence counterbalancing the subsequent positive influence. Secondly, there was a considerable shift in the policy environment between 2001 and 2013. Specifically, 2003 marked the advent of the split share structure reform, a period when the governance structure was in a transitional vacuum, during which managerial ownership had a notable impact. In 2013, the implementation of the “Corporate Governance Guidelines for Listed Companies” was comprehensive, and the regulatory framework for enterprises had matured to the extent that it would no longer significantly influence the size of the board of directors.

Concurrently, within the model that examines the board's independence, the impact of CEO duality and managerial ownership on board independence is found to be non-significant. However, the original data reveals a negative correlation between CEO duality and board independence, while managerial ownership is positively correlated with the same outcome. The observed discrepancy regarding CEO duality may be attributed to the fact that, following the 2006 revision of the Company Law, which served to strengthen the powers of independent directors, the authority of CEOs has been subject to a gradual constraint and restriction. Additionally, it is noteworthy that during the period of reform, there has been a gradual decline in the proportion of low-performing companies in China, accompanied by an improvement in the operational status of enterprises <sup>[6]</sup>. With regard to the disparities arising from managerial shareholdings, it is hypothesised that the root cause of this phenomenon may lie in the change in equity incentive methods for management. In 2003, the utilisation of stock options as a means of motivation was a prevalent practice among Chinese enterprises. In an effort to optimise the benefits derived from these options, management exhibited a propensity to augment the size of the board of directors, thereby facilitating the ratification of decisions that were conducive to their own interests. However, by 2013, the incentive method underwent a shift towards restricted shares <sup>[7]</sup>. Consequently, management became more focused on long-term stock price stability and no longer needed to deliberately control the board's size, thus maintaining the existing structure.

**Table 4.** Regression results of governance variables

	Model 1		Model 2	
	Coeff	SE	Coeff	SE
Constant	1.226***	0.107	0.233***	0.033
Supervisory-board	0.047***	0.004	-0.003*	0.001
Concentration	-0.128**	0.05	0.021	0.015
State-share	0.064	0.043	-0.019	0.013
CEO	-0.047**	0.017	0.008	0.005
Managerial-ownership	-0.11	0.081	0.003	0.025
Size	0.038***	0.005	0.006***	0.002
Age	-0.003*	0.001	0	0
Leverage	0.009	0.03	0.007	0.009
Profitability	-0.015**	0.005	0	0.002
Firm-value	0.009*	0.004	0.005***	0.001
R-squared	0.291		0.0422	
Observations	944		944	

## 2.4. Robustness test

In the robustness check section, this study employs the same variable substitution approach as the original paper, replacing “State-owned shares” with “State-holding + Legal person holding” and using “Sales revenue” instead of “Total assets” to measure firm size. Furthermore, the term “Revenue growth rate” has been substituted for “Profitability”. The outcomes resulting from these substitutions are analogous to those of the original model. Robust regression is furthermore employed to address the presence of outliers, thus ensuring that the outcomes are not significantly different from the original model, as shown in **Table 5**.

**Table 5.** Robustness checks result

Model 1		
	Coefficient	Std-Error
Constant	0.247***	0.029
Supervisory-board	-0.002*	0.001
Concentration	0.003	0.013
State-share	-0.004	0.012
CEO	0.007	0.005
Managerial-ownership	-0.006	0.022
Size	0.003*	0.001
Age	0	0
Leverage	0.008	0.008
Profitability	0	0.001
Firm-value	0.004***	0.001
Weighted-Independence	0.231***	0.014
R-squared	0.2614	
Observations	944	

## 3. New hypothesis

### 3.1. Background introduction

In 2001, the China Securities Regulatory Commission promulgated the “Guidelines on Establishing an Independent Director System in Listed Companies,” which stipulated that at least one-third of the board members in Chinese listed companies must be independent directors. This development signified the inception of the independent director system in China.

Nevertheless, it is important to note that early independent directors were frequently regarded as “ceremonial positions,” often nominated by major shareholders or management, and thus lacking true independence. Notable instances of this phenomenon include the “New Great Land Fraud Case,” which involved the presence of “token directors.” In this particular instance, the fraudulent activities perpetrated by

New Great Land Biotech Company were exposed, thus highlighting the need for rigorous financial oversight and regulatory enforcement. The investigation revealed that the independent directors had been recommended by the actual controlling shareholders and had never questioned the abnormal financial data <sup>[8]</sup>.

It is evident that the underlying cause of this phenomenon is predominantly attributable to two factors. Firstly, there is an evident absence of adequate supervision over related-party transactions. Secondly, there is a lack of financial independence.

It is encouraging that in 2012, as China comprehensively deepened its reforms, the state strengthened the system of independent directors. Since that time, the system has transitioned from a focus on “formal compliance” to a greater emphasis on “substantive performance,” thereby becoming an important counterbalancing force in corporate governance through regulatory enhancements, intensified accountability mechanisms, and improved market environments <sup>[9]</sup>. Moreover, the data indicates a significant reduction in the number of cases where companies experienced negative impacts due to inadequate oversight, compared to before. This prompts the following hypothesis: “the strengthening of the independent director system is positively correlated with the independence of the board of directors.”

### **3.2. Quantification and model establishment**

The enhancement of the independent director system can be reflected through two metrics: the proportion of independent directors and the network centrality of independent directors. In the establishment of the model, the data is first subjected to normalisation, after which a comparison and division of the normalised data is conducted to derive a weighted independence score. This process culminates in the attainment of a quantitative result for the strengthening of the independent director system. A higher weighted independence score indicates a higher proportion of independent directors on the board and that these independent directors occupy central positions within their professional networks.

### **3.3. Outcome presentation**

As demonstrated in **Table 5**, the coefficient of the weighted independence score is 0.231\*, signifying that for each unit increase in this score, the proportion of independent directors rises substantially by 23.1%. This finding suggests that the professionalism or quality of service of independent directors (such as background qualifications, attendance rates, and proposal quality) are the core factors driving this increase. The market’s assessment of independent directors has undergone a transition, shifting from a focus on “presence or absence” to “quality and effectiveness.”

Furthermore, the coefficient for the supervisory board is -0.002\*, yet its absolute value is negligible, suggesting that the supervisory function remains inadequately delineated. The relationship between independent directors and the supervisory board is characterised by its complexity and non-linear nature. It can be concluded that high-quality independent directors may collaborate with the supervisory board through specialised committees, rather than merely substituting for each other.

Recent studies have indicated that there is an increasing demand for the professionalism and performance quality of independent directors in today’s corporate society. This has resulted in more capable independent directors becoming involved in key corporate decisions, thereby leading to a decline in the phenomenon of “token directors”. Furthermore, as independent directors become more involved in corporate decision-making, the independence of the board is gradually increasing. Consequently, the validity of this study’s assumption is

confirmed, signifying a positive correlation between the enhancement of the independent director system and the autonomy of the board of directors.

## 4. Conclusion

A comparison of the governance mechanisms in 2013 with those in the period from 1999 to 2003 reveals distinct stage-specific characteristics. Traditional governance variables such as CEO duality and managerial shareholding exhibited diminished impacts, while the roles of policy rigidity and market mechanisms became more pronounced. It is noteworthy that the relationship between independent directors and the supervisory board has evolved from a simple functional substitution to a more complex collaborative model. Concurrently, the positive correlation between the proportion of independent directors and the company's market value serves as evidence of the market's recognition of governance quality.

Nevertheless, it must be acknowledged that this study is subject to several inherent limitations. Firstly, the sample is confined to A-share companies listed on the Shanghai Stock Exchange, which may compromise the generalizability of the findings. Furthermore, an analysis based solely on data from a single year fails to capture the long-term dynamic effects of policy reforms, potentially leading to discrepancies with actual conditions.

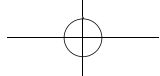
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