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Article

Coupling Coordinated Development of Ecological Environment and Digital Inclusive Finance in Ecologically Fragile Areas of Western China

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Abstract: This paper takes 12 ecologically fragile provinces in Western China as the research object, calculates the comprehensive evaluation value of ecological environment and the development level of digital Inclusive Finance of 12 provinces in Western China from 2011 to 2020 by constructing the evaluation index system, and analyzes the changes of ecological environment and digital Inclusive Finance coordination scheduling by using the coupling coordination degree model. The results show that: the overall ecological environment assessment of 12 provinces in the west is on the rise; The level of digital Inclusive Finance has also increased year by year. The coordination degree is on the verge of maladjustment to primary coordination, and the coordination index is on the rise, which indicates that the relationship between the western ecological environment and digital Inclusive Finance is gradually easing and tends to coordinated development.

Keywords: Ecological Environment; Digital Inclusive Finance; Coupling Coordination Degree Model; Open Grade Method

1. Introduction

Ecological environment, the basis of our survival, with the rapid development of the economy, natural resources are subject to excessive exploitation and utilization by human beings, and the problem of ecological deterioration is increasingly prominent, especially in the western ecologically fragile areas ecological environment has become a key issue that restricts regional economic development. With the concept of inclusive finance, some western provinces have gradually encountered financial services to achieve local economic development, so how to coordinate the development of ecological environment and inclusive finance is a problem we urgently need to solve. The inherent mechanism of the coordinated development of ecological environment and digital inclusive finance is to achieve common sustainable development, but coordinated sustainable development does not mean "equal development", but the development of mutual promotion and coupling between the two systems. Xiaonan Huang and Mu Zhang (2020) [1] used hesitant fuzzy language, gray correlation projection method measured the level of the two systems of ecological environment and financial agglomeration in Chinese provinces, then they used the coupling coordination model to empirically analyzed. The results showed that the coupling coordination

between ecological environment and financial agglomeration in Chinese provinces was not high, but their spatial patterns remained generally stable. Shengliang Su (2020) [2] made a comprehensive analysis of the development status of ecological environment and socio-economic development, the level of coupling and coordination, and the evolution trend of coupling degree in Ningxia Hui Autonomous Region as an example, which better reflects the coupling development process of interactive coercion between ecological environment and socio-economy in Ningxia. Peiyu Jia and Jianing Chen (2020) [3] used coupled coordination model and coordinated development theory to study the changing pattern of coordinated development level in ecologically fragile areas of Shanxi Province. The study shows that the overall level of coordinated ecological, resource and economic development in ecologically fragile areas of Shanxi Province has improved, with basic coordinated areas dominating. Peishan Tong and Shengxu Shi (2018) [4] used the PSR-GCQ model to conduct a comprehensive evaluation of the coupled and coordinated development of ecological environment and economic development in an urban agglomeration, and the study showed that the ecological and economic development of this urban agglomeration is well coordinated in time and space. Guofeng Gu and Xuehui Wang (2018) [5] analyzed the coupling relationship between economic development and ecological environment in Northeast China and its spatial and temporal evolution characteristics by using the gray correlation model, which showed that the coupling relationship between ecological environment and economic development in Northeast China is complex, among which excessive emission of pollutants and lack of water resources become the main factors limiting economic development.

To sum up, this paper selects the western ecologically fragile region as the research object, firstly, constructs the relevant index system of ecological environment and digital inclusive finance development level, selects the original data of 12 western provinces, cities and autonomous regions in the last ten years (2011-2020), and uses the pull-out grade method and comprehensive index method to measure the level; secondly, uses the coupled coordination degree model to empirically analyze the coordination of ecological environment and digital inclusive finance development, in order to provide scientific reference for the coordinated development of ecological environment and digital inclusive finance in the western ecologically fragile region.

2. Ecologically Fragile Area of Western China

In this paper, 12 provinces and autonomous regions (hereinafter referred to as: 12 provinces) in the western ecologically fragile region of China, including Guizhou, Chongqing and Sichuan, are selected and roughly divided into 3 regions according to their different ecological vulnerability characteristics. (1) Northwest desert oasis intersection ecologically fragile area, the administrative area involving Xinjiang, Gansu, Qinghai, Tibet and Inner Mongolia 5 provinces and autonomous regions. (2) Northern arid and semi-arid grassland region, the administrative area involves Shaanxi and Ningxia 2 provinces and regions. (3) The southwest karst mountain stone desertification ecological fragile area administrative area involving Sichuan, Guizhou, Yunnan, Chongqing, Guizhou and other five provinces and cities. The western region is located in an exceptionally fragile ecological environment, and the realization of coupled and coordinated development between ecological environment and socio-economic development in the western region is a key issue that needs to be addressed urgently to achieve regional ecological protection and high-quality development.

3. Measurement and Analysis of Ecosystem and Digital Financial Inclusion Level

3.1. Comprehensive Evaluation of Ecological Environment

The construction of an index system for western ecologically fragile areas is the basis for a comprehensive evaluation of their ecological environment, Jianning Yang (2011) [6] established natural environment indicators, economic environment indicators and social environment indicators based on the actual ecological environment in the west. Its sub-indicators include forest coverage rate, the total source of investment in forestry system fixed assets, the amount of water resources per capita, and a total of 18 indicators. Hongmei Zhang et al. (2019) [7] constructed an evaluation system including 15 secondary indicators in four subsystems: resources, environment, economy and society, and comprehensively evaluated the ecological and environmental conditions of 12 provinces, cities and autonomous regions in the western ecologically fragile region.

With reference to the above literature, this paper constructs a comprehensive evaluation index system of ecological environment in western ecologically fragile areas from three perspectives: environmental resources, economic development level, and social development level, as shown in Table 1. In this paper, 12 provinces from 2011 to 2020 were selected as the research sample, and the data were obtained from the China Environmental Statistical Yearbook, China Statistical Yearbook, and local statistical yearbooks, water resources bulletins, environmental bulletins, national economic and social development bulletins, RESSET financial research database, and Peking University Digital Inclusive Finance Index research reports in previous years.

Table 1. Comprehensive evaluation index system of ecological environment in ecologically fragile areas of western China.

	Indicator name (unit)
Environment and Resources	Forest coverage (%)
	Green space per capita (m^2)
	Comprehensive soil erosion control area (1000 hm^2)
	Per capita water holdings (m^3)
	Sulfur dioxide emissions (10,000 tons)
	Wastewater discharge (billion tons)
	Total investment in environmental pollution control (billion yuan)
	Area share of nature reserves (%)
Economic Development Level	Per capita disposable income of urban residents (yuan)
	Gross domestic product per capita (yuan)
	Per capita disposable income of rural residents (yuan)
	Total output value of agriculture, forestry, animal husbandry and fishery (billion yuan)
Level of Social Development	Total population (million people)
	Natural population growth rate (%)
	Engel coefficient (%)
	Number of students enrolled in general higher education schools (10,000)

3.2. Ecological Environment Level Measurement and Result Analysis

Minghua Wei et al. (2010) [8] adopted the pull-out grade method for the comprehensive evaluation of water environment, and the results show that the pull-out grade method can consider the influence of time on the evaluation results and improve the accuracy of the evaluation results, and this type of method is good for the comprehensive evaluation of ecological environment. In this paper, after fully examining the environmental characteristics of the western region, it is proposed to measure and analyze the ecological environment level of 12 western provinces, cities and autonomous regions using the pull-out grade method, and the research process is as follows: Suppose there are m evaluation objects $S_1, S_2, \ldots, S_m$, n evaluation indicators $q_1, q_2, \ldots, q_n$, and arranged $t_1, t_2, \ldots, t_r$ chronologically from the original data $\{s_{ij}(t_k)\}$, $\{s_{ij}(t_k)\}$ composed a timing stereo data table. A comprehensive evaluation problem supported by a time-series stereo data table, called a dynamic comprehensive evaluation problem can be generally expressed as:

$$y_i(t_k) = F\{w_1(t_k), w_2(t_k), ..., w_m(t_k); q_1(t_k), q_2(t_k), ..., q_n(t_k)\}, i = 1, 2, ..., n; k = 1, 2, ..., r$$

Among them $y_i(t_k)$ indicates the comprehensive evaluation value of the evaluation object S_i at the moment t_r, F denotes the analytic equation of the function, $w_i(t_k)$ indicates weighting factor of the evaluation object q_i at the moment t_r.

The pull-down grade method is to take the composite evaluation function:

$$y_i = w_1 q_{i1} + w_2 q_{i2} + ... + w_n q_{in}, i = 1, 2, ..., n$$

to determine the value of w_i is to make the difference between evaluation objects S as large as possible, differences between evaluation subjects can be indicated by

$$\sigma^2 = \sum_{i=1}^{m} (y_i - \bar{y})^2$$

after standardizing raw data:

$$\sigma^2 = \sum y_i^{\ 2} = Y^T Y = (WX)^T (WX) = W^T HW$$

we will get, when restrict $\|W\| = 1$, get the eigenvector corresponding to the largest eigenvalue of the symmetric matrix H of W, σ^2 takes the maximum value the feature vector at this point is the corresponding weight of each index, and then brought into the comprehensive evaluation function to obtain the comprehensive evaluation value of the system.

The change trend of the comprehensive evaluation of ecological environment by regions is shown in Figure 1.

As can be seen from Figure 1: (1) The overall eco-environmental assessment values of the 12 provinces increased and decreased during the period 2011-2020 but showed an overall increasing trend with a moderate magnitude, indicating that the ecological environment in the western region tended to improve, the ecological vulnerability decreased, and the structure and function of the ecosystem improved and enhanced during the study period. (2) Except for some individual provinces which showed a decline in a certain year, it basically developed in an upward trend. Among them, Sichuan, Qinghai, Tibet, Inner Mongolia's ecological environment is significantly better than the other

eight provinces, and in recent years, with the country's continued attention to the ecological development of the west, Inner Mongolia's ecological environment has achieved a major reversal. Green lock sand throat, yellow sand into oasis, this is just a microcosm of the ecological realization of a major reversal in Inner Mongolia. (3) Due to the continuous economic development and urbanization construction in recent years, Guizhou, Ningxia and Gansu have paid too much attention to economic development instead of pollution control, resulting in the deterioration of the ecological environment, making their ecological environment comprehensive evaluation value in the 12 provinces fell in the back of the comprehensive ranking, this overall comprehensive ranking is more consistent with the actual ranking and has some reference value.

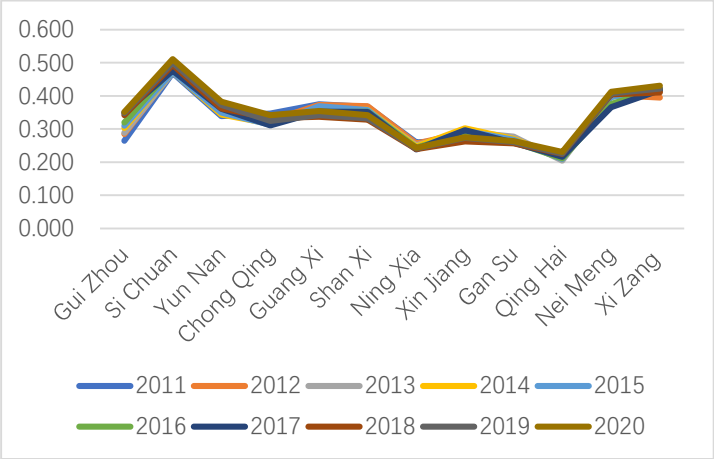

Figure 1. Comprehensive evaluation value of ecological environment in 12 provinces in western China.

3.3. Measurement and Analysis of the Development Level of Digital Financial Inclusion

The key to this paper is how to build a digital financial inclusion measurement system that meets the realities of the western region. Feng Guo et al. (2020) [9] enriched the traditional financial inclusion evaluation system by considering the breadth of digital financial services and the multi-level and diversified nature of digital financial services and compiled the "Peking University Digital Financial Inclusion Index" covering 31 provinces, 337 cities above prefecture level and about 2,800 counties in mainland China. This paper refers to and cites the Peking University Digital Inclusive Finance Index research report, and takes logarithms of digital inclusive finance in 12 provinces to obtain the trend of its development level as shown in Figure 2.

From Figure 2, it can be seen that: (1) On the whole, the evaluation value of digital inclusive finance development in western ecologically fragile regions has increased and stabilized year by year, indicating that the development level of digital inclusive finance in western ecologically fragile regions is improving year by year, which is related to the national vigorous development of digital economy in recent years. (2) 2011-2012 to enhance the speed very quickly after 2013 to enhance the rate tends to be stable, the development space is larger, to achieve leapfrog development. By region, the level of digital financial inclusion development in Xinjiang, Gansu, Qinghai, Inner Mongolia and Tibet, which are in the ecologically fragile zone of the northwest desert oasis junction, has been increasing year by year but is lower compared with other ecologically fragile zones, and the relatively poor environment, water shortage and infertile land have limited the development of the local economy. The development of digital inclusive finance in five provinces and autonomous regions, namely Sichuan, Chongqing, Yunnan and Guangxi, has performed relatively well, among which

Sichuan and Chongqing have a fragile environment, but Chengdu in Sichuan, as a typical national strong provincial capital, has stimulated the development of its surrounding economy, and Chongqing, as a municipality directly under the central government, has led the western region, while Guizhou, Yunnan and Guangxi, although their initial levels are low, are gradually narrowing the gap through government support and orderly local development.

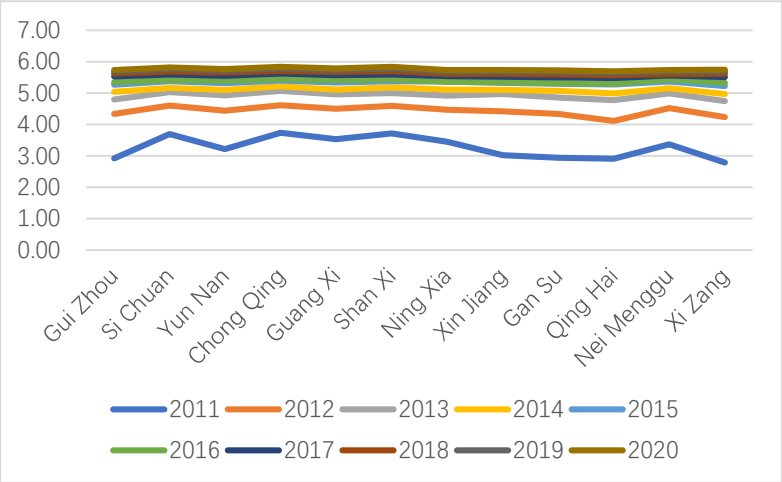

Figure 2. The level of development of digital financial inclusion in 12 provinces in western China.

4. Coordination Degree Model Construction and Result Analysis

4.1. Coupling Coordination Evaluation Method and Result Analysis

Table 2. Coupling coordination degree interval and grade.

No.	Coherence value	Coordination level
1	0.000-0.10	Extreme disorder
2	0.1001-0.20	Severe disorder
3	0.2001-0.30	Moderate disorder
4	0.3001-0.40	Mild disorder
5	0.4001-0.50	Nearly dysfunctional
6	0.5001-0.60	Barely coordinated
7	0.6001-0.70	Primary coordination
8	0.7001-0.80	Intermediate coordination
9	0.8001-0.90	Good coordination
10	0.9001-1.00	Quality coordination

Coupling refers to the phenomenon of interaction and influence of multiple systems. The coupling degree can scientifically measure the strength of this action, and according to the research content of this paper, the coupling degree function can be set as:

$$C = \sqrt{W_1 * W_2} / (W_1 + W_2)$$

where C is the coupling degree. It is used to measure the strength and weakness of the interaction between systems or elements, while the degree of coordination is the relationship between systems

or elements in a coordinated and virtuous cycle, reflecting the degree of system coupling. The larger the value, the higher the coupling degree. Coupling Coordination Function is as:

$$T = \alpha W_1 + \beta W_2, \quad E = \sqrt{C * T}$$

where E is the coupling coordination degree and T is the comprehensive evaluation index. α , β are TBD factors, set them both to 0.5. In this paper, the uniform distribution function method is used to delineate the intervals and levels of coupling coordination as shown in Table 2.

4.2. Analysis of Coupling Coordination Degree Results

The coupling coordination model was used to measure the coupling coordination between the ecological environment and the level of digital financial inclusion in 12 provinces from 2011 to 2020, which was analyzed by SPSS 25.0, and the results are shown in Table 3.

Table 3. Coupling and coordination of ecological environment and digital inclusive finance in 12 provinces in western China.

	Coupling coordination									
province	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gui Zhou	0.3323	0.4821	0.5438	0.5853	0.6219	0.6396	0.6848	0.6977	0.7036	0.7057
Si Chuan	0.4660	0.5871	0.6518	0.6736	0.7105	0.7232	0.7516	0.7766	0.7863	0.7921
Yun Nan	0.3811	0.5199	0.5902	0.6130	0.6498	0.6671	0.6936	0.7133	0.7322	0.7413
Chong Qing	0.4365	0.5337	0.5964	0.6180	0.6453	0.6598	0.6809	0.7081	0.7101	0.7135
Guang Xi	0.4221	0.5370	0.5982	0.6201	0.6612	0.6651	0.6931	0.7025	0.7053	0.7108
Shan Xi	0.4404	0.5488	0.6024	0.6325	0.6627	0.6704	0.6959	0.7019	0.7064	0.7134
Ning Xia	0.3775	0.4860	0.5414	0.5761	0.6173	0.6177	0.6491	0.6605	0.6701	0.6805
Xin Jiang	0.3417	0.4943	0.5686	0.5927	0.6235	0.6209	0.6551	0.6496	0.6557	0.6001
Gan Su	0.3347	0.4761	0.5463	0.5730	0.6045	0.6038	0.6420	0.6552	0.6623	0.6712
Qing Hai	0.3704	0.5017	0.5879	0.6226	0.6685	0.6740	0.7071	0.7272	0.7305	0.7401
Inner Mongolia	0.4142	0.5512	0.6188	0.6438	0.6792	0.6818	0.6972	0.7241	0.7321	0.7368
Xi Zang	0.3614	0.5099	0.5907	0.6218	0.6635	0.6812	0.7113	0.7286	0.7345	0.7423

Based on the comprehensive evaluation index of ecological environment and socio-economic development, the coupling coordination degree model was used to calculate the coupling coordination degree index of ecological environment and digital inclusive finance in the study area from 2011 to 2020, as shown in Table 3 and Figure 3.

The analysis led to the following conclusions: (1) Overall, the coupling coordination index of the ecological environment and the development level of digital inclusive finance in the western region shows an increasing trend year by year, indicating that the relationship between the ecological environment and the development level of digital inclusive finance in the study area is improving and tends to be coordinated, and the coupling coordination degree shows a rapid increase, indicating that the ecological environment system and the digital inclusive finance system gradually tend to develop harmoniously and coordinate under human intervention. The level of coordination has been increasing. The regions develop from near-dissonance and mild dissonance to primary coordination level. (2) By region, the coordination level of the five provinces and autonomous regions of Xinjiang,

Gansu, Qinghai, Inner Mongolia, and Tibet is relatively low compared with other regions but the gap is gradually narrowing. (3) The coupling and coordination of the five provinces and autonomous regions of Sichuan, Guizhou, Chongqing, Yunnan and Guangxi is better than that of other ecologically fragile regions, while Guizhou, as a national important big data development base, is in an economic upswing and neglects the coordinated development of ecological environment and economy, resulting in its coupling and coordination degree is not high. (4) Shaanxi and Ningxia provinces face greater environmental pressure, which hinders economic development, but Shaanxi has a superior geographical location and a more complete industrial structure, and its coupling coordination degree is also considerable.

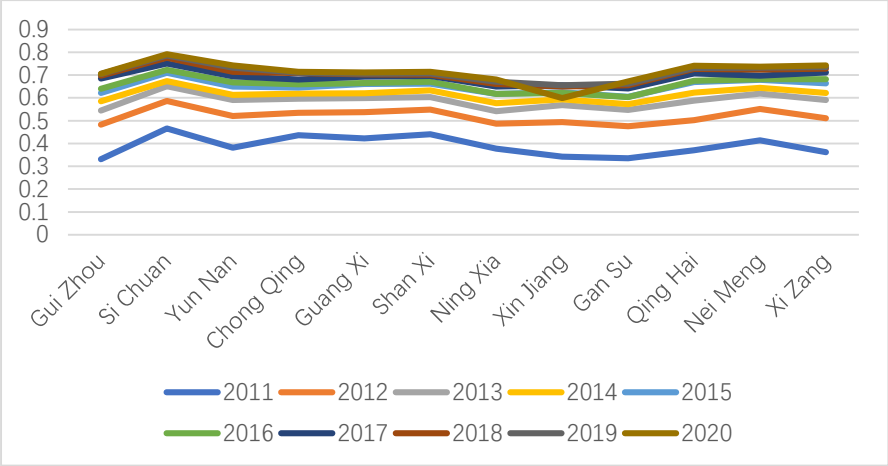

Figure 3. Coupling and coordination of ecological environment and digital financial inclusion levels in 12 provinces in western China.

5. Conclusions

By studying the coupling coordination degree of ecological environment and digital inclusive finance in the western ecologically fragile regions from 2011 to 2020, we find that the level of digital inclusive finance development in the western region has been increasing, the quality of ecological environment has been improving, and the coupling coordination development index has been rising, but in terms of its coupling coordination development type, 12 provinces are still in the primary coupling coordination development stage, compared with coastal areas and other Compared with coastal areas and other regions, there is still a large gap. This is not only related to their fragile ecological background and scarce natural resources, but also to their industrial structure and development mode. The coupled and coordinated development of ecological environment and digital inclusive finance is influenced by a variety of factors. This paper mainly analyzes and studies the degree of coupled and coordinated development of digital inclusive finance and ecological environment in western ecologically fragile areas, but does not study its evolutionary characteristics, evolutionary mechanism and driving mechanism, which is also the focus of this paper for further research in the future.

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