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# Assessing the Environmental and Economic Impacts on Industry Informatization for Ningxia's Renewable Energy Development

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**Abstract.** This paper analyzes the informatization process of Ningxia's renewable energy industry, its impact on the environment and economy, and uses the coupling coordination degree and grey correlation method to construct a system covering government policies, technological progress, new energy development trends, natural environment and other factors, which can comprehensively evaluate the informatization process in Ningxia and the impact on local renewable energy. Firstly, the coupling coordination degree is used to calculate the relationship between industrial information and renewable energy, and then the gray correlation analysis method is used to evaluate the impact index of Ningxia's renewable energy industry informatization, and corresponding suggestions are taken. The results of the model analysis show that the informatization of Ningxia's renewable energy industry can have a positive impact on the environment and economic development, and there is a strong correlation between the informatization process of Ningxia's renewable industry and government support, Ningxia's economic level, and natural environment quality. The process of informatization is closely related to government policies, technological progress, new energy development trends, and environmental factors, and the optimization of the new energy structure can improve the sustainability of Ningxia's economy, so improving the above content can promote the development process of renewable energy in Ningxia.

**Key words.** Renewable Energy, Information Environment, Green Economy, Informatization Process, Solar Energy.

## 1. Introduction

Ningxia has more wind and power resources, making it an ideal region for new energy development. However, the effect of new energy development in Ningxia is not ideal, and it cannot promote each other with the local economy, and the entry point of new energy and local economic development has been found [1], [2], which is the focus of current research. For the development of new energy in Ningxia, some scholars believe that the coupling algorithm should be used for analysis [3], [4], but the one-way coupling can not find the entry point, and the impact of the entry point is not ideal, so some scholars suggest that the two-way coupling scheduling method should be used to achieve the integration between different indicators [5], taking into account the relationship between the development of new energy and the local economy [6], but there is still the problem of high deviation rate of the results [7], so some scholars believe that the dynamic coupling method should be used to mediate the development of new energy and local economic indicators, so as to achieve the organic combination of the two, so this paper improves the coupling method and analyzes the dynamic coupling scheduling model [8]. The purpose of this study is to deeply analyze the coordinated development of the informatization environment and economy of Ningxia's renewable energy industry, and to introduce a research method based on the coupling coordination model and the grey correlation method to comprehensively explore the impact of informatization of Ningxia's renewable energy industry on the environment and economy. Although independent, the two are closely linked, and coordinated development plays a key role in promoting economic expansion and social progress. Based on the above background, the focus of this study is to find ways to deal with these challenges in the process of collaborative progression, and to introduce an exploratory method based on the coupled scheduling model and the grey correlation method. The coupled scheduling model is helpful in measuring the synergistic progress of the informatization environment economy of Ningxia's renewable energy industry, and the grey correlation law can reveal the connection and interaction between the two, and deeply explore the impact evaluation of the informatization environment and economy of Ningxia's renewable energy industry, so as to make a positive contribution to the long-term stable growth of the economy and society. The specific research process is shown in Figure 1.

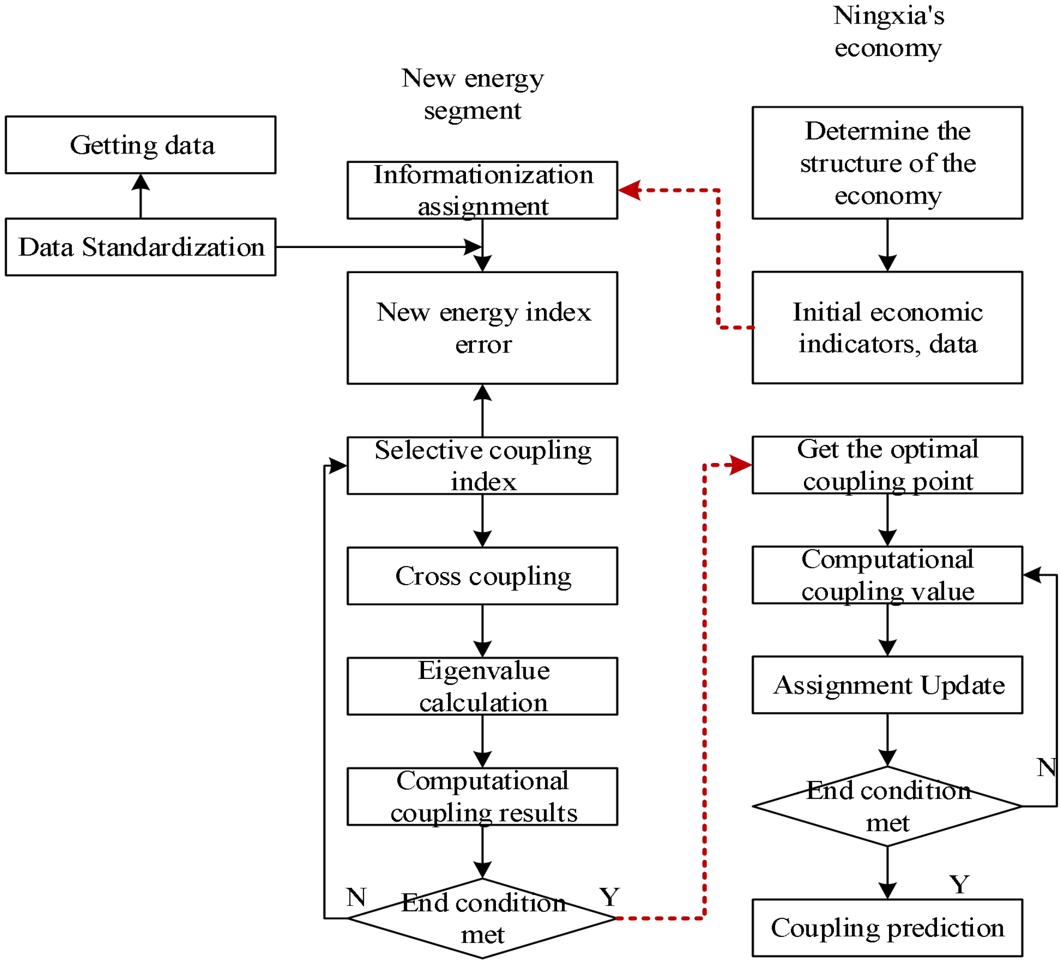


Fig. 1. Informatization Process of New Energy and Local Economy

## 2. Related Concepts

*A. Selection of Systematic Evaluation Index System*

As a key means, the evaluation index system can conduct an in-depth evaluation of the economy and renewable energy in Ningxia, and lay a foundation for finding the entry point of the two in the later stage. The mathematical description of coupling coordination degree and grey correlation method is established, and the text description of each index is carried out to form the mathematical transformation of the problem, so as to study the environmental and economic synergy of Ningxia renewable energy industry, so it is of great significance to construct a scientific and appropriate evaluation index system for the optimization scheme.

Hypothesis 1: Informatization is $x_i$, new energy development is, $y_i$ and the coupling model is $f(x, y)$, then the coupling relationship between informatization and new energy is shown in equation (1).

$$f(x,y) = k \cdot \sum x_i \cdot y_i \,|eci \quad (1)$$

Among them, $k$ is the coupling coefficient and $eci$ the economic development, which is a constraint. Then, find the coupling relationship between the two, calculate, *max f(x, y)* and calculate the formula as shown in (2).

$$\max f(x,y) = k \cdot \sum x_i \cdot y_i \,|eci > \min[f(x_i, y_i)] \quad (2)$$

$min[f(x_i, y_i)]$ is the result of optimal coupling, but not the result of final coupling.

According to equation (1) and equation (2), the coupling parameter table between Ningxia informatization and new energy is obtained with reference to relevant literature at home and abroad, as shown in Table 1 and Figure 2.

Table 1. Evaluation Index System of Renewable Energy Industry and Information-based Environmental Economy

| Target | Level 1 Indicators | Secondary Indicators |
|---|---|---|
| Renewable Energy Industry (xi) | Market trends (x1)<br><br>Government policies (x2)<br><br>Organizational and environmental factors (x3). | Renewable energy industry, informatization, environment, economic growth, profit margin<br>Return on Investment (x11)<br>Employment rate (x12)<br>Per capita income(x21)<br>Social contribution(x22)<br>Environmental Protection (x23)<br>Resource Utilization Efficiency (x31) |
| Information Environment Economy (yi) | Innovation ability (y1). | Ecological balance( x32)<br>Scientific and technological innovation capability (y11)<br>Product Innovation Capability (y12)<br>Management Innovation Capability (y13) |

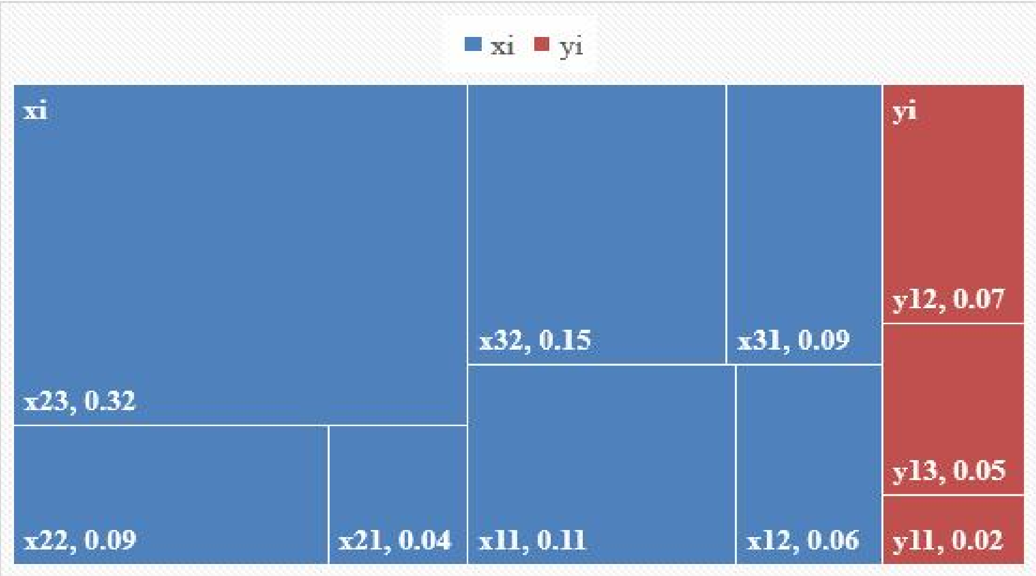


Fig. 2. Weights and Tree Maps of the Evaluation Index System

*B. Dynamic Adjustment of the Evaluation Index System*

In this study, we were able to construct dynamic evaluation criteria and propose the following hypotheses.
Hypothesis 2: The dynamic adjustment of the indicator system is $M(x_i, y_i)$ as follows, in which the new energy revenue is *in*, the profit reporting rate is *ir*, the information technology is *it* and the new energy structure itself *ns*.

$$M(x_i, y_i) = in \cdot k_1 + ir \cdot k_2 + it \cdot k_3 + ns \cdot k_4 + \Delta k \quad (3)$$

It can be seen that other parameters in Ningxia can be ignored [9], and through the analysis of parameters, we can understand the relationship between new energy development and economic development, as well as the evaluation criteria of government policies, including wage ratio, per capita income and social contribution, on the results. The coupling of information technology and renewable energy cannot improve the economy of a society and have a positive impact on the social fabric.
In order to reduce the influence of the amount of information data on the results, this paper maps the initial data and obtains its open value, so as to realize the standardized processing of the data, and the result is shown in equation (4).

$$[x_i, y_i] \to [\log \vec{x}_i, \log \vec{y}_i] \quad (4)$$

From equation (4), this study can analyze these data and carry out spatial mapping to eliminate interfering factors such as scientific and technological innovation, commodity innovation, and management innovation.

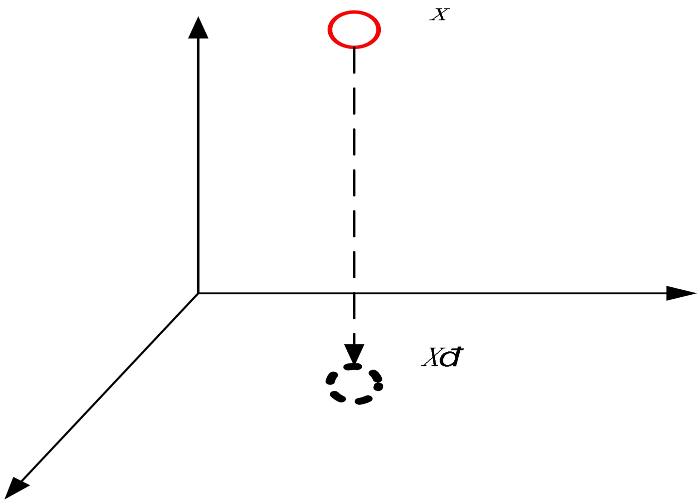


Fig. 3. Standardized Processing of Data

As can be seen from Figure 3, the standardized processing of data can reduce the complexity of data, and more accurately study the impact of informatization and renewable energy, as well as the coupling results of the two, so as to enhance the industrial competitive advantage of Ningxia. By standardizing the data, it will be possible to understand the coupling results. An evaluation coupling model can be constructed from the perspectives of economic and natural environment to find out factors such as environmental maintenance, resource utilization efficiency and ecological balance. In addition, the coupling analysis of informatization, environment and economy of Ningxia's new energy industry is conducive to the coordinated growth of economy, society and environment. Standardization studies can be used to understand the impact of coupling results on environmental, economic, and other factors [10], [11], [12]. In general, the establishment of a coupling index system and data standardization can provide support for the informatization, environmental and economic research of Ningxia's new energy industry, and analyze the multi-dimensional role of new energy development trends, government policies, technological progress and natural environment. Through the evaluation of data standardization, we can gain an in-depth understanding of the effectiveness of the coupling and synergy of different indicators, provide support for the formulation of appropriate optimization strategies in the later stage, and promote the collaborative promotion of the informatization environment and economy of the new energy industry in Ningxia.

### *C. Measure the Coupled Entropy Weight of New Energy and Economy*

Before creating a coupling coordination model, the study had to measure the growth of the system. As a commonly used measurement method, the entropy method can measure the growth of a system by calculating the entropy of each metric [13]. The core idea of the entropy method is that the wider the distribution of values, the greater the growth of the system. The specific process is as follows:
The entropy weight of new energy, the relevant data covers all parameters of Ningxia's new energy information environment and economy. These parameters are normalized and converted to values from 0 to 1. The entropy value of each metric is calculated using the following formula:

$$\text{Entropy} = -\sum \text{Ai} * \text{Bi}\ (\text{pi} * \log(\text{pi})) \tag{5}$$

where *pi* is the proportion of the metric value. The weights for each metric are calculated using the following formula:

$$\text{W} = (1 - \text{Entropy}) / (\text{n} - \sum (1 - \text{Entropy})) \tag{6}$$

where *n* is the number of indicators. The weights of each indicator are added together to get the level of development of the system.

The entropy weight of the economy aims to measure the progress of the informatization environment and economic coordination of Ningxia's renewable energy industry. Based on the coupling theory, the model delves into the interactions between different industries and their impacts to assess their progress in coordination [14], [15], [16], [17]. The specific steps are as follows: the core parameters of Ningxia's new energy industry informatization environment economy have been established, such as industrial scale, output, total number of employees, etc. Establish a coordination model to convert the associations of all parameters into a coupling matrix. The degree of coupling between the indicators is calculated as follows:

$$\text{OH} = \sum (\text{Eoh}\ (\text{i,j}) * \text{W(i)} * \text{W(j)}) \tag{7}$$

The coupling matrix (i,j) indicates the degree to which the i-th metric affects the j-th indicator, and the weight (i) represents the weight of the i-th parameter. The level of progress together in the information technology and renewable energy industries is measured by the intensity of their interconnectedness.

The grey correlation between renewable energy and the economy measures the correlation between different indicators, and it is necessary to determine the intercorrelation of each indicator, and determine the impact of each indicator on the final coupling, as well as the outcome. The specific steps are as follows:

The collection of relevant reference data covers all reference materials in the information technology and renewable energy industries. Each metric is normalized and converted to a value between 0 and 1. The correlation between the indicators is calculated as follows:

$$\mathrm{Rel} = \sum^{\sum|x(i)-y(i)|} (1 - |x(i) - y(i)|/\max \quad (8)$$

where x(i) and y(i) represent the value of the ith indicator in the information environment, economy, and renewable energy sectors, respectively. Measure the role of each factor in collaborative growth based on the strength of the correlation. On this basis, a coupled scheduling model can be established in this study, and the grey correlation analysis method can be used to measure the synergistic growth level of the information-based environmental economy and the renewable energy industry [18], [19]. This will lead to decision-making and promote the coordinated development of Ningxia's new energy industry in the information environment and economy.

## 3. An Empirical Study on the Coupling and Coordinated Development of Informatization Environment and Economy in Ningxia's Solar Energy Industry

*A. Data Sources*

The data are mainly derived from the Ningxia Economic Statistical Yearbook (2022~2023), as well as official public statistics provided by government departments, industry alliances, or other appropriate institutions. At the same time, according to CNKI, Wanfang and other websites, statistical resources were obtained, and the materials were carefully selected, and the "Ningxia Informatization and New Energy Development Questionnaire" was obtained, and experts were interviewed, and the final investigation report could be obtained with the help of comprehensive interpretation of relevant academic materials. In addition, combined with various academic journals, seminars, books and research reports, as well as historical data, as an aid, the initial data of Ningxia's new energy industry informatization was finally obtained. Finally, the initial data were standardized to remove irrelevant attributes of the data to support later studies [20], [21]. At the same time, SPSS software was used for data analysis, and the data indicators with significant differences were found, and $P<0.05$ was used as the cut-off point for analysis (Figure 4).

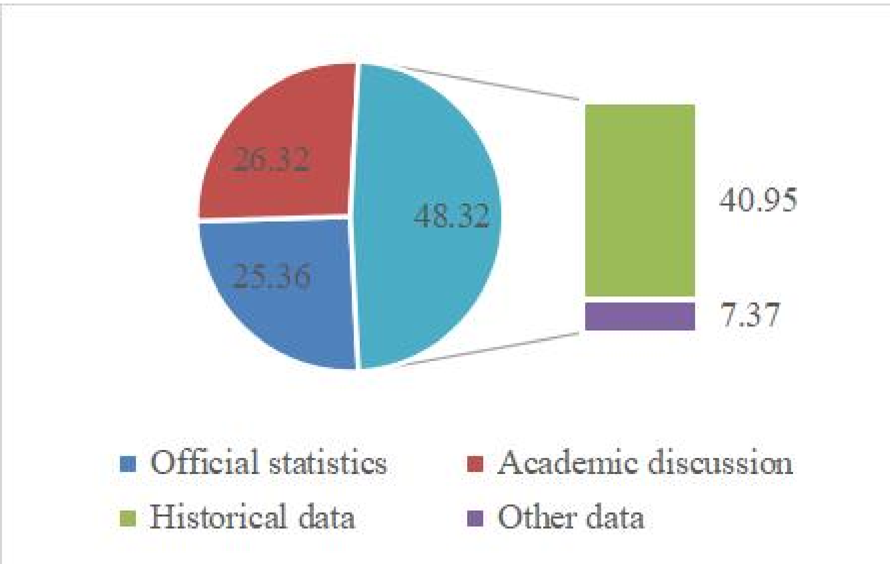


Fig. 4. Description of Data Sources and Percentages

*B. Analysis of Empirical Results*

*1) Analysis of the environmental and economic coupling degree (correlation effect) of the informatization of renewable energy industry in Ningxia*

The degree of coupling is defined as the connectivity or interaction between the information, environmental, economic and renewable energy industries. Table 2 lists the reference criteria for evaluating coupling, and measures the strength of the connectivity according to their respective value intervals. A value between (0, 0.2) indicates a weak connectivity. This suggests that the IT and renewable energy industries are not very connected and do not play a significant role in each other. It is likely that their communication is sparse because their paths of progress, their goals and the needs of the market are very different. In the area of (0.2, 0.4) [22], [23], it represents stubbornness. This suggests that the informatization of Ningxia's solar energy industry is deepening the connectivity of the environment and economy, and some interacting trends have been revealed. It is likely that the advancement of information technology has stimulated the innovation and growth of the renewable energy industry, and perhaps the needs of the renewable energy industry have also contributed to the expansion of information technology. In the area of (0.4, 0.7), it represents a state of harmony. This implies the close connection of Ningxia's solar energy industry, informatization, environment and economy, as well as their strong interaction. It is likely that because of their close dependence, their growth and prosperity are all promoted together. When the value is between (0.7 and 0.9), it represents a strong degree of coupling [24], [25], [26], [27].

Table 2. Criteria for Discriminating the Environmental and Economic Coupling Degree (C) of the Informatization of Renewable Energy Industry in Ningxia

| Value range (0, 0.2) | (0.2, 0.4) | (0.4, 0.7) | (0.7, 0.9) |
|---|---|---|---|
| Low-level coupling | Stubborn | grind in | High level of coupling |

Combined with Table 2, it can be seen that the close connection between the informatization environment and economy of Ningxia's solar energy industry is extremely deep, and its interaction effect is extremely obvious. They likely work closely with each other, supporting and motivating each other, and together they promote growth. Based on the above evaluation indicators, this study has the opportunity to explore the degree of integration of the informatization environment and economy of Ningxia's solar energy industry. In the case of a low degree of coupling, this study can find strategies to improve the relationship between the two to achieve better communication effects and bring shared benefits. However, when the degree of coupling increases, this study can further develop the possibility of synergy between the two and accelerate the synergy and development of the industry [28]. In short, studying the degree of linkage between the information environment economy and the renewable energy industry can help the study understand their linkages and make effective decisions. As long as the collaboration and communication between these two fields are continuously enhanced, a healthy interaction between the information environment economy and the renewable energy industry can be achieved to promote their synergistic growth.

*2) Analysis of the coordination degree of environmental and economic coupling of informatization of renewable energy industry in Ningxia*

The coupling coordination degree measures the closeness of the informatization environment and economy of Ningxia's solar energy industry. In Table 3, we can see the range of values for each parameter and their corresponding level of coordination. Next, the study will interpret the data in detail. First and foremost, the level of coordination will be determined based on the degree of coupling. When the degree of coupling increases, the connection between the information environment economy and the renewable energy industry will become more compact, and the degree of cooperation will correspondingly increase. Conversely, if the degree of coupling is reduced, then the connection becomes more detached and the degree of collaboration is correspondingly reduced. When this number ranges from (0, to 0.1), the study can be seen as severely uncooperative and in a declining phase. This suggests that there is a significant imbalance in the relationship between the information technology sector and the renewable energy industry, which has the potential to lead to profound confrontations and disputes. In the range of (0.1, 0.2), the degree of equilibrium is highly disrupted by ACK.

Table 3. Discriminant Criteria for the Coupling Coordination Degree (D) of the Environment-economy of the Informatization of the Renewable Energy Industry in NingxiaQuestions concerning the preparation of papers may be addressed to the International Secretariat:

| Value Range | Level of Coordination | The Stage You are in |
|---|---|---|
| (0, 0.1) | Extreme dysregulation | |
| (0.1, 0.2) | Severe dysregulation | Drop stage |
| (0.2, 0.3) | Moderate dysregulation | |
| (0.3, 0.4) | Mild dysregulation | |
| (0.4, 0.5) | On the verge of dysregulation | Run-in phase |
| (0.5, 0.6) | Barely coordinated | |
| (0.7, 0.8) | Intermediate coordination | |
| (0.8, 0.9) | Good coordination | A stage of benign development |
| (0.9, 1) | High-quality coordination | |

Although the linkage between the information environment economy and the renewable energy industry has not yet reached complete harmony, there are some traces of progress in this study compared to the serious imbalance. On a scale of (0.2, 0.3), the degree of harmony is defined as moderate. This suggests that although there is a degree of disharmony between the linkage between the information environment economy and the renewable energy industry, they may be gradually moving towards a harmonious track. When the study sets the range of (0.3, 0.4) to slight dissonance, it means that a process of adaptation is underway. This suggests that although the linkage between the information technology and renewable energy industries has reached a certain degree of harmony, some problems remain to be solved. When the study sets the range of (0.4, 0.5) to be close to dissonance, the study can be seen as on the verge of collapse. This suggests that the linkages between the IT and renewable energy industries are becoming more strained, and the level of coordination must be increased. In the range of (0.5, 0.6), the degree of cooperation can be understood as reluctant cooperation. This shows that although there is some degree of synergy between the information technology and renewable energy industries, there are still some shortcomings. When the values are between (0.7, 0.8), this study can be considered as moderately coordinated, indicating that it is entering a healthy growth period. This means that the IT and renewable energy industries are more closely linked and have achieved some degree of synergy. When the values are between (0.8, 0.9), this study can be regarded as an excellent degree of synergy. This shows that the information technology and renewable energy industries are extremely well connected and have made remarkable progress. In the range of (0.9,1), the degree of harmony is ACK for high-quality harmony. This means that the information technology and renewable energy industries are extremely tightly linked, and the harmonious results are excellent.

In general, an in-depth study of the convergence and collaboration between the information environment economy and the renewable energy industry will enable this study to better understand their linkages, and at the same time to design appropriate strategies according to their degree of integration and their current development status.

Analysis of the coupling degree and coupling coordination degree between the renewable energy industry and the information environment and economy

The results in Table 4 show that the interconnectedness and synergies between the renewable energy and IT sectors have improved significantly over the past few years. More specifically, from 2018 to 2022, the values of the correlation indicators (U1 and U2) continued to rise, suggesting that the renewable energy industry is increasingly linked to the IT sector.

Table 4. Coupling Degree and Coupling Coordination Degree between Renewable Energy Industry and Information Environment Economy

| Year | Ui | U2 | T | C | Relevance | D | Coordination Level | Lag Level |
|---|---|---|---|---|---|---|---|---|
| 2018 | 0.203 | 0.11 | 0.153 | 0.836 | High level of coupling | 0.401 | On the verge of disorder | The information environment and economy are lagging behind |
| 2019 | 0.363 | 0.293 | 0.336 | 0.970 | High level of coupling | 0.56 | Barely coordinated | |
| 2020 | 0.470 | 0.505 | 0.503 | 0.951 | High level of coupling | 0.60 | Intermediate coordination | Renewable energy industry and information-based environmental economy |
| 2021 | 0.651 | 0.703 | 0.627 | 0.923 | High level of coupling | 0.817 | Good coordination | The renewable energy industry is lagging behind |
| 2022 | 0.753 | 0.972 | 0.867 | 0.971 | High level of coupling | 0.913 | High-quality coordination | |

Overall, in recent years, the degree of linkage and cooperation between the renewable energy industry and the digital economy has increased significantly. Although there was still a slight lack of cooperation and backwardness in the early stage, however, with the passage of time, the degree of linkage between the two has begun to be significantly improved and balanced. This reveals that the interaction and dependence between the renewable energy industry and the digital economy are gradually increasing, which brings greater possibilities and problems to the progress of the renewable energy industry.

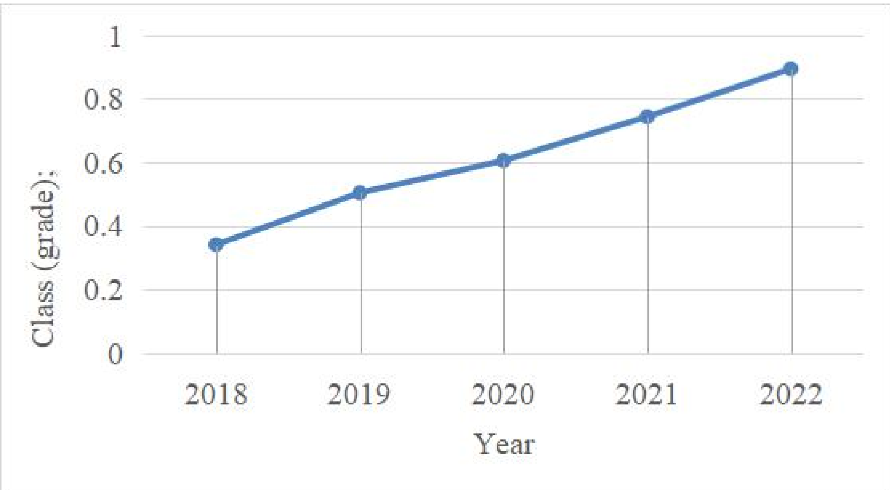

Fig. 5. Comparison of Coupling Results at Different Times

From the results of Figure 5, it can be seen that the coupling trend between new energy and Ningxia's economy is an upward trend, and the rising rate is relatively stable, indicating that informatization can promote the development of coupling degree. For in-depth analysis, the indicators in informatization are analyzed to find out the main change indicators, as shown in Figure 6.

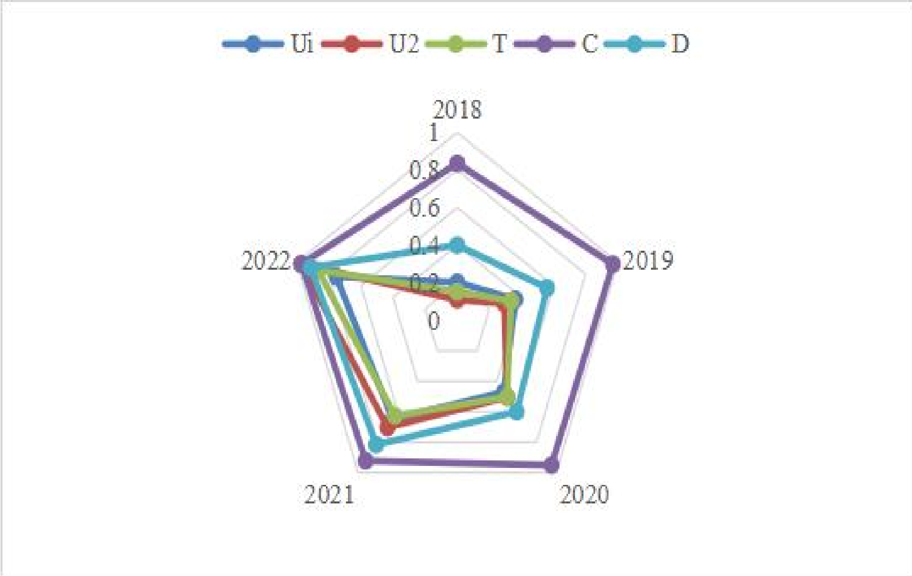

Fig. 6. The Degree of Change of Different Indicators

As can be seen from Figure 6, the influence of the C index is relatively large, followed by D, Ui and T, and the influence of the U2 index is the least, so it is necessary to increase the research on the C index and give full play to the advantages of informatization. Based on the above analysis results, the correlation analysis of different indicators is carried out, and the specific results are shown in Table 5.

Table 5. Correlation between Different Indicators and New Energy Sources

| | **New Energy** | **Ui** | **U2** | **T** | **C** | **D** |
|---|---|---|---|---|---|---|
| Local economy | 1 | | | | | |
| Ui | 0.71** | 1 | | | | |
| U2 | 0.12 | 0.14 | 1 | | | |
| T | -0.36** | 0.13 | -0.07 | 1 | | |
| C | -0.06 | -0.08 | 0.16 | -0.03 | 1 | |
| D | 0.37 | -0.04 | 0.01 | -0.25* | 0.02 | 1 |

p<0.05 ** p<0.01

The correlation of each indicator is described for the results in Table 5, as shown in Figure 7.

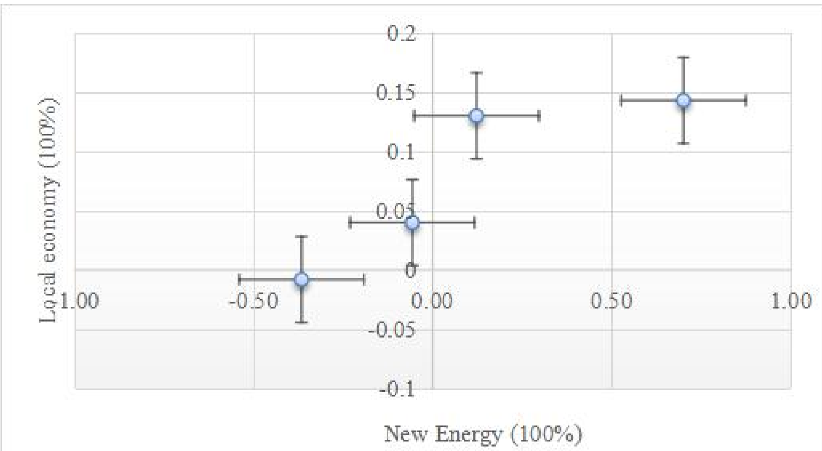

Fig. 7. Correlation between Local Economy and New Energy

As can be seen from Figure 7, there is a positive correlation between the local economy and new energy, and the correlation between the two is gradually strengthened, indicating that informatization can promote the coupling of local economy and new energy, promote the development of new energy, and create a good economic environment for it.

C. *Recommendations*

*1) Strengthen cooperation and exchanges in the informatization environment and economy of the renewable energy industry*

The informationization process of staff-increasing industry belongs to a linkage process, which should link theoretical research with practical activities and form an interactive relationship between production, education and research. For example, the seminar on new energy informatization, the forum on new energy technology and the discussion on the necessity of new energy informatization, etc., provide a good external environment for the informatization process. In the process of new energy informatization, it is necessary to realize interdisciplinary cooperation, improve the informatization proportion of products and the informatization service quality, optimize the whole new energy industry structure, and enhance its informatization competitiveness in the market.

*2) Increase policy support for the informatization of the renewable energy industry and the environment and economy*

In order to promote the common growth of the renewable energy industry, information-based environment and economy, the government has the ability to strengthen policy support in these two fields. For example, the ability to implement tax breaks incentivizes companies to invest and innovate in both areas. On the other hand, the government can also strengthen the support for the basic equipment structure and personnel training of the renewable energy industry, so as to bring a better growth atmosphere and conditions to the renewable energy industry.

*3) Focus on sustainable development and environmental protection*

To promote the common progress of the information environment economy of the renewable energy industry, this research needs to focus on its sustainable and high-quality economic development. The study can establish some relevant rules and regulations to motivate the company to implement environmental protection measures in the process of operation and management and reduce the waste of resources and environmental damage. On the other hand, the study will also enhance the promotion and education of environmental protection concepts in the renewable energy industry, thereby enhancing the public's understanding and awareness of long-term development.

## 4. Conclusion

Through the connection and coordination between Ningxia's new energy information environment and economy, and the analysis of SPSS software, it is found that informatization can promote the development of new energy and optimize the local economic structure, so informatization can improve the development level of new energy. The results show that the promotion level of informatization to new energy and local economy is at a high level, with a value of 0.913, a medium level of 0.817, and a low level of 0.401, indicating that the promotion effect is obvious. In terms of coupling, the high level is (0.9, 1) and the low level is (0, 0.1), indicating that the gap between the two is obvious, which shows that informatization can promote the development of Ningxia's economy, improve the quality of the local environment, and optimize the social and economic structure. The indicators investigated in this paper include profit margin, return on investment, and structural optimization of the renewable energy industry, so the research results of information technology also show the role of the above indicators, Ningxia region should adopt new energy innovation technology, put forward the corresponding symmetry, promote the informatization process of social progress industry, and give full play to the advantages of informatization. In addition, the auxiliary indicators in this study, including high-quality environment and intensive economic development, have also been shown to have weak effects. In general, there is a mutually reinforcing relationship between the informatization process of the new energy industry and the renewable energy industry. Government policies, new energy development trends and natural environment are important indicators to evaluate the process of informatization, and they are also important factors to promote the process of new energy informatization. Of course, there are some shortcomings in this study, mainly because the information in the survey results is not general, only for Ningxia region, the coverage of the research results is relatively weak, and the amount of survey data is insufficient..

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