Evaluation of Macroeconomic Ecological Environment Development from the Perspective of Sustainable Development

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Abstract: With the development of ecological economic theory, people are more and more aware of the importance of ecological environment to economic development. The establishment of a good economic and ecological environment is conducive to improving the utilization rate of resources and waste and the ecological efficiency of the macro economy. This is also conducive to realizing the harmonious unity of sustainable economic growth, environmental protection and the improvement of residents' well-being. However, there are still some problems in the macro-economic ecological environment in some regions, which hinder the ecological and sustainable development of the macro-economy. Therefore, based on the perspective of sustainable development, this paper analyzed the development of macroeconomic ecological environment, and built an evaluation system for the level of macroeconomic ecological development. Some suggestions were put forward to improve the level of macroeconomic ecological development, and the experimental study was carried out on the level of macroeconomic ecological development in N province. The research showed that the average improvement rate of economic development indicators in N province was 30.74%, and the average improvement rate of ecological efficiency indicators in N province was 29.91%.

1. Introduction

In recent years, some areas have not paid attention to the harmonious relationship between economic development and ecological environment protection in the process of economic development, and have not done the work of protecting the ecological environment while developing the economy. Therefore, the waste of ecological environment resources and environmental pollution problems are caused [1]. This not only affects the harmonious relationship between man and nature, but also negatively affects the sustainable development of the economy. The construction of a good economic and ecological environment is conducive to providing sufficient raw materials, energy and other material foundations for macroeconomic development, and providing a solid guarantee for economic development; this is conducive to reducing people's

resource consumption in production and life, improving economic and ecological efficiency, and reducing ecological environment pollution; it is conducive to promoting the high-quality development of the macro economy and improving the overall level of the macro economy. Therefore, this paper studied the development of macroeconomic ecological environment based on sustainable development [2].

2. Theoretical Framework of Macroeconomic Ecological Environment Investigation

The theoretical basis of macroeconomic ecological environment research consists of three parts, as shown in Figure 1, which are non-equilibrium system theory, ecosystem theory and management theory.

Disequilibrium
system theory

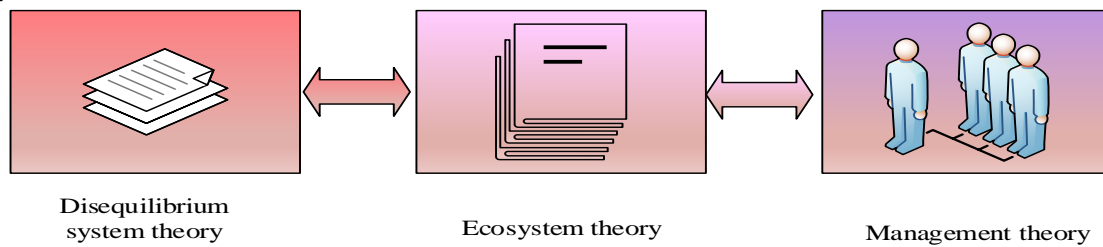Ecosystem theory

Management theory

Figure 1: Theoretical basis for macroeconomic ecological environment research

Non-equilibrium system theory is a discipline that masters the regularity of complex systems through the study of complex systems. It has a wide range of applications, such as the analysis of physical and chemical phenomena, the research in the field of biological evolution, the optimization of social and economic environment, etc. Ecosystematics originated in the field of biology. However, with the continuous development of social economy, the connotation of ecological environmental systematics is constantly developing [3]. As the intensity of human activities continues to increase and the scope of activities continues to expand, problems have arisen in the synergistic relationship between humans and the natural ecological environment and between humans. Therefore, the ecological environment system theory has been applied to the field of human society and economy, so as to coordinate the economic relationship between natural ecology and economic development, and between people, and achieve sustainable development of human society and economy. The management theory is in the process of continuous update and improvement, and some new management concepts and management thinking are constantly being put forward; compared with the mechanical characteristics of the traditional organizational structure, the structure of economic organizations is more and more characterized by flat management and organic management; the change of the ecological relationship between economic organizations makes the boundary of economic organizations become more blurred [4].

3. Evaluation System of Macroeconomic Ecological Development Level and the Weight of Evaluation Indicators

Through the research on the economic ecology, this paper constructs an evaluation system for the development level of the macro-economic ecology. The specific content is shown in Figure 2.

As shown in Figure 2, the first-level evaluation indicators of the macroeconomic ecological development level are economic development indicators, government support indicators, energy consumption and emission indicators, and ecological efficiency indicators. The secondary indicators of economic development indicators mainly include the total economic production, the economic production of the tertiary industry, the proportion of the production value of the tertiary industry, the amount of patent authorization, and the Engel coefficient; the secondary indicators of the

government support index include the government's investment level in ecological governance, the cost of water conservancy and environmental investment and construction, the economic investment in industrial pollution control, and the level of investment in scientific and technological development support; the secondary indicators of the energy consumption and emission indicators are the emission of sulfur dioxide, the level of chemical oxygen demand and the total amount of energy consumption; the secondary indicators under the eco-efficiency index are the comprehensive utilization rate of industrial waste, the energy consumption per unit of industrial product, and the conversion rate of energy processing [5].
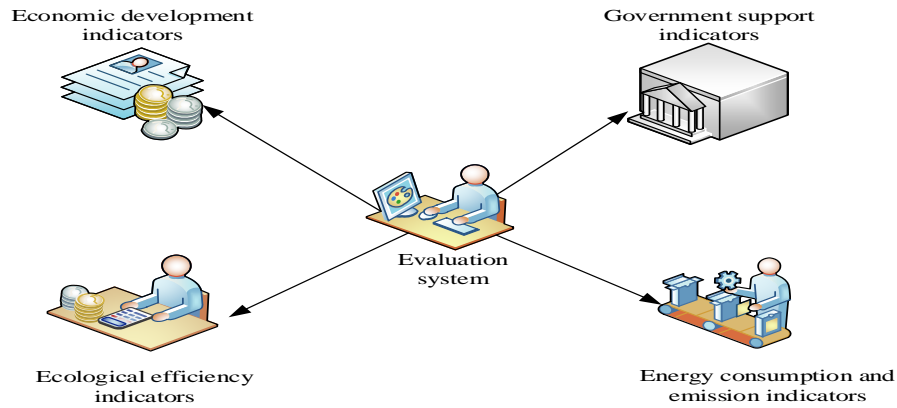

Figure 2: Evaluation system of macroeconomic ecological development level

The analytic hierarchy process is adopted to calculate the weights of evaluation indicators, and the specific results are shown in Table 1.

Table 1: Weight measurement results of evaluation indicators

First-level indicator	First-level indicator weight	Secondary indicators	Secondary indicator weight
Economic development indicators	0.4579	Total economic production	0.4627
		Output value of the tertiary industry	0.1538
		Proportion of the tertiary industry	0.2036
		Patent authorization	0.0713
		Engel coefficient	0.1086
Government support indicators	0.1682	Ecological governance investment	0.1689
		Water conservancy environment investment	0.1267
		Industrial pollution control	0.3123
		Scientific and technological development support	0.3921
Energy consumption and emission indicators	0.0635	SO2 emissions	0.1259
		Chemical oxygen demand levels	0.5072
		Total energy consumption	0.3669
Ecological efficiency indicators	0.3104	Comprehensive utilization rate of industrial waste	0.26
		Energy consumption per unit of industrial product	0.24
		Energy processing conversion rate	0.5

As shown in Table 1, in the evaluation system of macroeconomic ecological development level,

the weight of economic development index and ecological efficiency index is relatively high, and the weight of economic development index is 0.4579. Among the secondary indicators of economic development indicators, total economic production has the highest weight. The weight of the ecological efficiency index is 0.3104, and the higher weight of the secondary index is the energy processing conversion rate.

4. Suggestions on Improving the Development Level of Macroeconomic Ecological Environment

To improve the development of the macroeconomic ecological environment, including optimizing the industrial structure, increasing investment in ecological technology, establishing a sound ecological environmental protection system, adhering to the concept of sustainable development, and developing a circular economy. As shown in Figure 3.

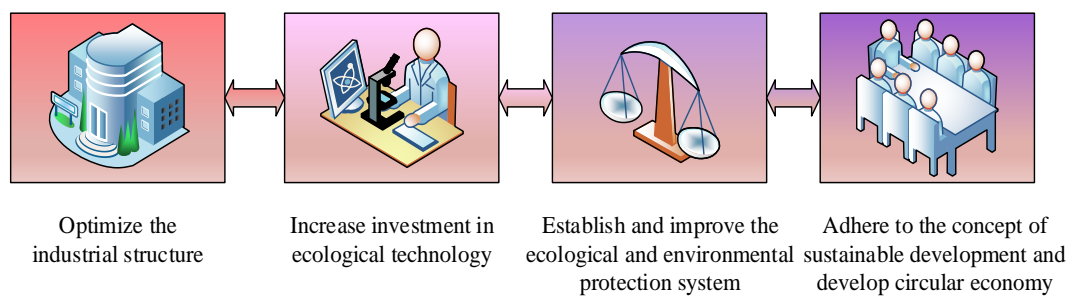| Optimize the industrial structure | Increase investment in ecological technology | Establish and improve the ecological and environmental protection system | Adhere to the concept of sustainable development and develop circular economy |

Figure 3: Suggestions for improving the level of macroeconomic ecological environment development

(1) Optimization of industrial structure
The optimization of the industrial structure reflects the development of high-tech industries, the optimization of energy industries, and the transformation and upgrading of traditional industries. High-tech industries are knowledge-intensive industries, which can reduce damage to the ecological environment while maintaining high economic development efficiency. The economic and ecological efficiency of high-tech industries is high, so the government should actively develop high-tech industries. The transformation and upgrading of traditional industries refers to the use of advanced technology and production management concepts to upgrade and transform traditional manufacturing industries and promote manufacturing enterprises to have their own independent brands, thereby enhancing the proportion of high-end products produced by manufacturing enterprises in the total products, and increasing the number of independent intellectual property rights of manufacturing enterprises [6].

(2) Increased investment in ecological technology
The increase in investment in ecological technology is mainly reflected in improving the utilization rate of natural resources, improving the ability to prevent and control pollution, and promoting the application of clean energy. The improvement of the utilization rate of natural resources can be started from the following aspects: The management of water resources is strengthened and the water resources are saved. The specific measures are to carry out dynamic and real-time pollution detection of water resources, apply intelligent irrigation technology, and improve and optimize sewage treatment technology; the land ecological protection is effectively realized, the land resource database system is optimized and perfected to realize the rational planning and management of land resources. The investment in farming technology is increased to improve the utilization efficiency of land resources; the level of forest product processing technology has been continuously improved, and the utilization rate of forest resources has been improved. The

improvement of pollution prevention and control capabilities is based on the improvement of air pollution control capabilities, water resources governance capabilities, and soil pollution control capabilities. Anti-pollution and pollution control technologies are continuously improved and updated to achieve effective governance of the ecological environment.

(3) The establishment and improvement of the ecological and environmental protection system

Improvement of the ecological environment supervision mechanism: In terms of supervision methods, information-based supervision methods are used to improve the management ability of supervisors and increase the enthusiasm of the public to participate; the expansion of the scope of ecological environment supervision should not only manage the ecological environment in the industrial field, but also effectively supervise the ecological environment in the agricultural field. The quality of the ecological environment of large enterprises should be supervised, and the impact of small and micro enterprises on the ecological environment cannot be ignored; the responsibilities of the main body of ecological environment supervision should be clearly divided, and individuals should actively report to the relevant departments the ecological environment damage behavior of enterprises. Enterprises should establish the awareness of ecological economy and strengthen their own supervision. The ecological environment supervision and supervision department should improve its own supervision level to prevent enterprises from damaging the ecological environment. In addition, effective ways to establish and improve the ecological and environmental protection system also include enhancing the regional ecological compensation system and improving the ecological performance appraisal system.

(4) The adherence of the concept of sustainable development and development of circular economy

It is necessary to adhere to the concept of sustainable development and circular development, and cultivate and improve people's awareness of saving. Educational activities for sustainable economic development and circular economy development should be carried out to regulate people's consumption behavior; it is necessary to promote the sustainable development of circular production methods, improve the circular production capacity of enterprises, and continue to improve the circular economy industrial chain; it is necessary to improve the degree of resource sharing between cities and villages and give play to the leading role of cities, so as to increase government support and promote balanced economic development.

5. Utilization Algorithm for Economic and Ecological Efficiency Prediction

The use of information entropy theory, kernel function, kernel principal component analysis and other methods to strengthen the early warning and control of macroeconomic ecological environment and coordinate the relationship between macroeconomic development and natural ecological environment can promote the ecological and sustainable development of macroeconomic.

(1) Information entropy theory

The information entropy of the source is:

$$L(\chi) = L(I_1, I_2, ..., I_n) = -I(\chi_p)\log I(\chi_p) \tag{1}$$

Among them, $I(\chi_p)$ is the probability of the p-th character output by the source, and let the formula be:

$$\sum_p I(\chi_p) = 1 \tag{2}$$

When a random sequence is used to represent the actual information source, the expression formula of information entropy is:

$$L(\chi) = -\sum_{\chi} I(\chi) \log I(\chi)$$

(3)

The calculation steps of information entropy are:
The data of economic and ecological efficiency indicators are normalized:

$$r_{pq} = \frac{1}{10} + \frac{9}{10} * \left(\alpha_{pq} - \min_{1 \le p \le n}(\alpha_{pq}) \right) / \left(\max_{1 \le p \le n}(\alpha_{pq}) - \min_{1 \le p \le n}(\alpha_{pq}) \right)$$

(4)

The information entropy of each economic eco-efficiency index is obtained:

$$F_q = -c \sum_{p=1}^{n} u_{pq} \ln(u_{pq})$$

(5)

u_{pq} and c satisfy the following conditions:

$$u_{pq} = r_{pq} / \sum_{p=1}^{n} r_{pq}$$

(6)

$$c = 1/\ln n$$

(7)

(2) Kernel function

$C(\chi_1, \chi_2)$ is set as the economic eco-efficiency kernel function on $U^n \times U^n$, and the formula is as follows:

$$C(\chi_1, \chi_2) = (\phi(\chi_1) * \phi(\chi_2))$$

(8)

Among them, $(*)$ is the inner product.

In this paper, Gaussian radial kernel function, polynomial kernel function and radial basis kernel function are used in the evaluation of economic and ecological efficiency. Their expression formulas are as follows:
The expression of the Gaussian radial kernel function is:

$$C(\chi, \chi_p) = \exp\left(-\frac{|\chi - \chi_p|^2}{\mu^2} \right)$$

(9)

The expression of the polynomial kernel function is:

$$C(\chi, \chi_p) = [k\chi \bullet \chi_p + \sigma]^b$$

(10)

Among them, k and σ are the polynomial kernel function parameters about the economic and ecological efficiency, and b is the order of the kernel function.
The expression of radial basis kernel function is:

$$C(\chi, \chi_p) = \tanh[\beta(\chi \bullet \chi_p) + k]$$

(11)

(3) Kernel principal component analysis

The vector X about the economic eco-efficiency index is mapped to a high-dimensional space G. It is transformed to $\Phi(X)$ and made to satisfy the following conditions:

$$\sum_{p=1}^{n} \Phi(X) = 0 \tag{12}$$

The covariance matrix in the high-dimensional space G is:

$$\overline{K} = \frac{1}{n}\sum_{q=1}^{n} \Phi(x_q)\Phi(x_q)^s \tag{13}$$

The eigenvalues and eigenvectors of the economic eco-efficiency index are obtained from formula $\varepsilon W = \overline{K}W$, and the following formulas can be obtained:

$$\varepsilon(\Phi(X_c) \cdot W) = (\Phi(X_c) \cdot \overline{K}W) \tag{14}$$

The $n \times n$ th order matrices C and $C_{pq} = \Phi(x_p) \cdot \Phi(x_q)$ are defined to exist and the formula is as follows:

$$n\varepsilon\alpha = C\alpha \tag{15}$$

The projection of $\Phi(x)$ on W is:

$$(W^c \cdot \Phi(x)) = \sum_{p=1}^{n} \alpha_p^c (\Phi(x_p)\Phi(x)) = \alpha_p^c c(x_p, x) \tag{16}$$

Since $\sum_{p=1}^{n} \Phi(X) = 0$ is an assumption in an ideal state, it is necessary to replace matrix C with matrix C'_{pq} in practical applications. The expression formula of the matrix C'_{pq} is:

$$C'_{pq} = C_{pq} - \frac{1}{n}\sum_{k=1}^{n} 1_{pk}C_{kq} - \frac{1}{n}\sum_{e=1}^{n} C_{pe}1_{eq} + \frac{1}{n^2}\sum_{k,e=1}^{n} 1_{pk}C_{ke}1_{eq} \tag{17}$$

6. Experimental Investigation on the Level of Macroeconomic Ecological Development

The macroeconomic ecological development level evaluation system was applied to study the macroeconomic ecological development level of N province, and the economic development index data, government support index data, energy consumption and emission index data, and ecological efficiency index data of N province from 2017 to 2021 were standardized. Calculate the development of the four indicators from 2017 to 2021. Specific experimental data are as follows:

(1) Economic development indicator data of N province

The data of economic development indicators in N province are counted and sorted, including indicators such as total economic production, economic production of the tertiary industry, etc. The specific content is shown in Figure 4.
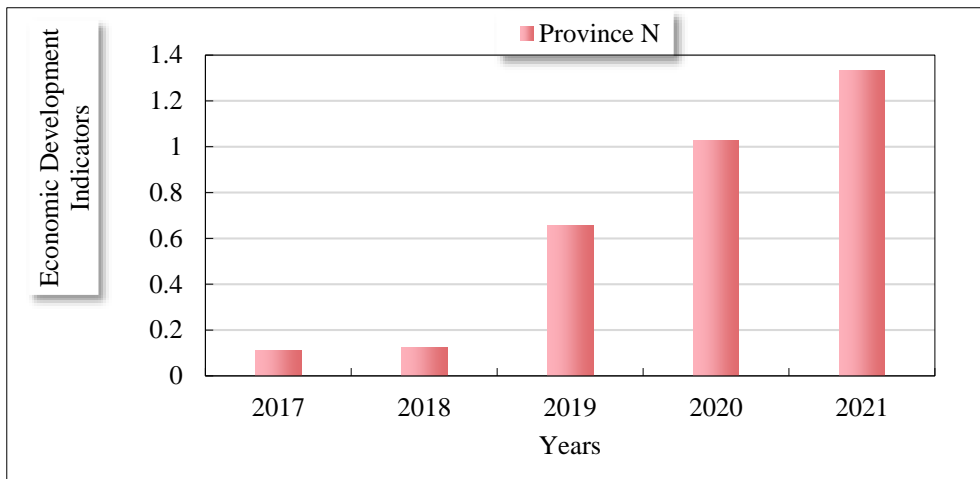
Figure 4: Economic development indicator data of N province

As shown in Figure 5, on the whole, the economic development indicators of N province have been on the rise, which shows that the economic development of N province from 2017 to 2021 is relatively stable. The economic development index of N province in 2017 is 0.1103. In 2021, the economic development index of N province reaches 1.3326. From the final result, the economic development of N province is relatively good. From 2017 to 2018, the economic development index of N province increases by 13.96%; from 2018 to 2019, the economic development index of N province increases by 22.99%; from 2019 to 2020, the economic development index of N province increases by 56.21%; from 2020 to 2021, the economic development index of N province increases by 29.78%. From 2017 to 2021, the average growth rate of economic development indicators in N province is 30.74%.

(2) Government support indicator data in N province

The government's investment level in ecological governance and the cost of water conservancy and environmental investment and construction are sorted and recorded, and the relevant data on the government support indicators of N province are obtained, as shown in Figure 5.
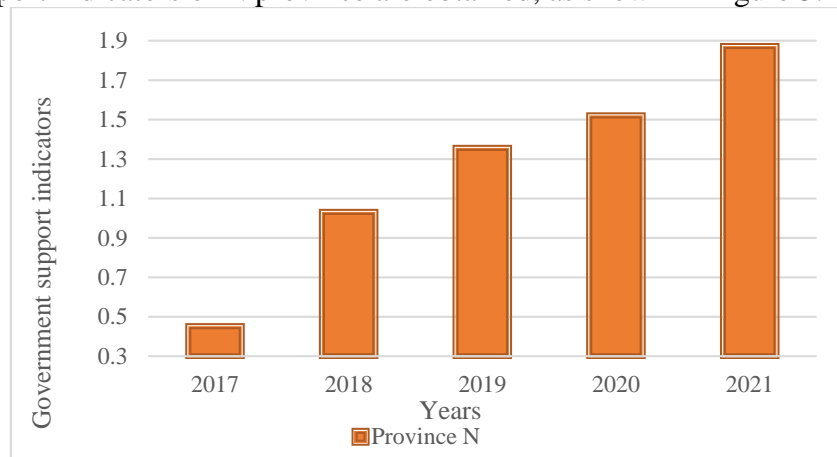

Figure 5: Government support indicator data for province N

As shown in Figure 5, from 2017 to 2021, the government support indicator of N province has been on an upward trend, which shows that N province has been carrying out macroeconomic ecological environment governance. From the specific data, in 2017, the government support index of N province is 0.4523; in 2021, the government support index of N province reaches 1.8734. The government support index of N province in 2021 is 1.4211 higher than the government support

index in 2017, and the improvement effect is very obvious.

(3) Energy consumption and emission index data of N province

The three indicators data of treated sulfur dioxide emission, chemical oxygen demand emission level and total energy consumption are sorted out, and the indicator data about energy consumption and emission in N province are obtained. The results are shown in Figure 6.
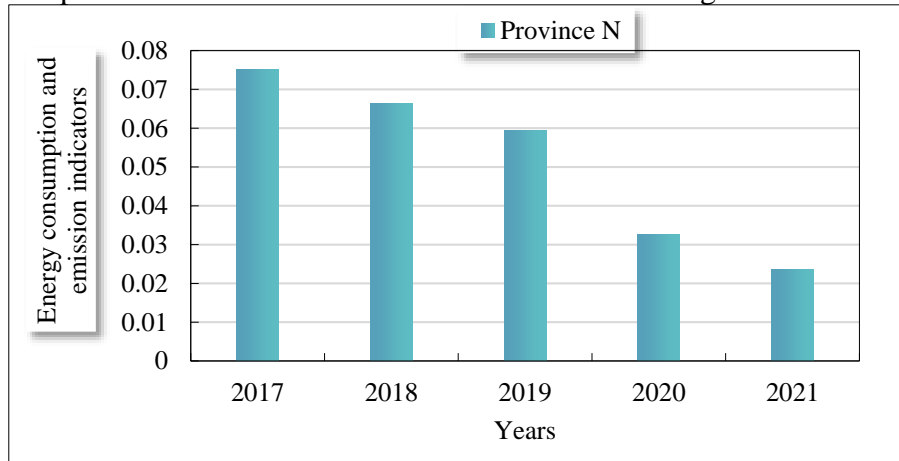

Figure 6: Energy consumption and emission index data in N province

As shown in Figure 6, overall, the energy consumption and emission index data of N province has been in a downward trend. The energy consumption emission index of N province is 0.0752 in 2017 and 0.0237 in 2021. The difference between the two is 0.0515, and the energy consumption and emission index of N province has dropped significantly. Although economic growth is inseparable from energy consumption, economic growth cannot rely too much on energy consumption. Energy utilization efficiency should be improved. The reduction of energy consumption and emission indicators in N province is conducive to the development of N province's macroeconomic ecological environment.

(4) Eco-efficiency index data of N province

The comprehensive utilization rate of industrial waste, the energy consumption per unit of industrial products, and the conversion rate of energy processing are recorded to obtain the index data on the ecological efficiency of N province. The results are shown in Figure 7.
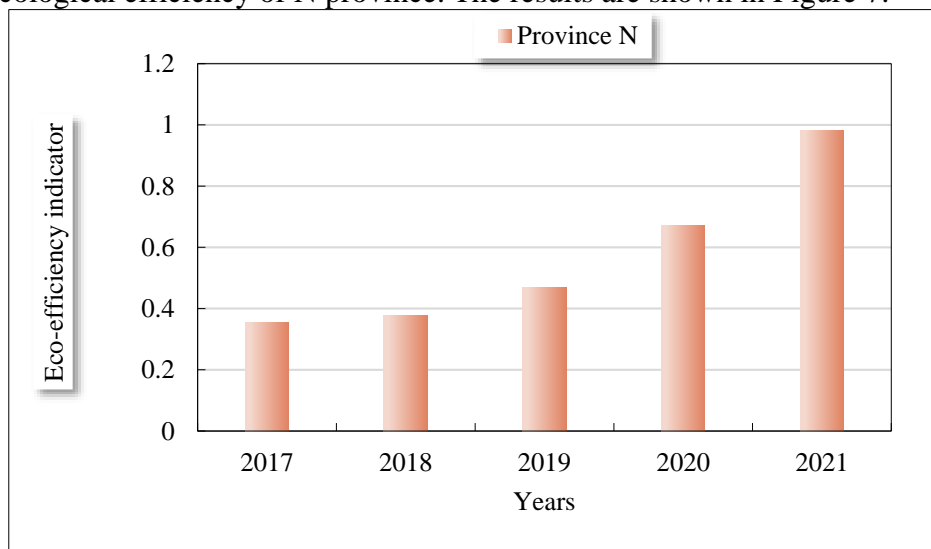

Figure 7: Eco-efficiency indicator data in N province

As shown in Figure 7, from the perspective of development trends, the eco-efficiency index data of N Province has been in a growing trend. The eco-efficiency index of N province is 0.3562 in 2017 and 0.9814 in 2021. The improvement effect is more obvious, but the improvement effect is not as good as the economic development index and government support index of N province. The eco-efficiency index of N province in 2018 increases by 5.53% compared with the eco-efficiency index in 2017. The eco-efficiency index of N province in 2019 increases by 24.69% compared with the eco-efficiency index in 2018. The eco-efficiency index of N province in 2020 increases by 43.35% compared with the eco-efficiency index in 2019. The eco-efficiency index of N province in 2021 increases by 46.06% compared with the eco-efficiency index in 2020. From 2017 to 2021, the average improvement rate of ecological efficiency indicators in N province is 29.91%.

7. Conclusions

In order to promote the ecological and sustainable development of macro-economy, on the basis of constructing the evaluation system of macro-economic ecological development level and the weight of evaluation indicators, the research experiment was conducted on the macro-economic ecological development level of N province by using evaluation indicators, and the following conclusions were drawn: In recent years, the economic development indicators and ecological efficiency indicators of N province have been significantly improved, the macroeconomic ecological environment management has been strengthened, the economic investment level has been improved, and the energy consumption and emission indicators have shown a downward trend.

Acknowledgements

References

[1] Lin C W, Lv Q H, Zhang H R. Comparative Evaluation of the Development Level of Creative Cities in China's Economic Zones: An Empirical Study Based on Economic Ecosystem Theory [J]. Science and Technology and Economics, 2017, 30(6):26-30.

[2] Shang S Z, Yang Z Q. Evaluation of coordinated development of Jiangsu marine economic ecosystem [J]. Continental Bridge Vision, 2022, 13(1):31-33.

[3] Zhang J C. Evaluation of the Coupling and Coordinated Development of my country's Agricultural Economy and Ecosystem [J]. Ecological Economy, 2022, 38(6):115-121.

[4] Jin S J. Research on the strategic control of environmental costs of Chinese enterprises under the ecological economic development model [J]. Times Finance, 2018, 691(9):136-141.

[5] Gadzhiev N G, Konovalenko S A, Trofimov M N. Ecological Economy: The Most Important Aspect of the Ideology of the Global Commons in Supporting Sustainable Socio-Economic Development[J]. South of Russia ecology development, 2020, 14(4):17-24.

[6] Wang B, Zhang L, Wang D, & Jiang G. The Impact of E-Commerce on Urban Green Innovation Development: Evidence from Chinese Cities. Journal of Organizational and End User Computing, 2023, 35(1), 1-21.