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*Research Article*

# An Evaluation Model of an Urban Green Finance Development Level Based on the GA-Optimized Neural Network

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The construction of a green financial system can promote economic transformation and development, scientifically and effectively evaluate the green environmental protection level of finance in different cities, and provide a strong impetus for its future promotion. This paper introduces a BP neural network into the evaluation system of urban green finance progress and optimizes the model through GA. According to the constructed evaluation index system, this paper makes empirical analysis of the experimental city. The optimization results show that GA can improve the training error range of the BP neural network and increase the stability of evaluation model performance and the accuracy of evaluation results. Through empirical analysis, it is concluded that the development status of the urban economy, the mode and efficiency of capital distribution, and the degree of support for the environmental protection industry in terms of policy and capital will have a great impact on the development of its environmental protection finance. The support attitude of the local government and society in energy conservation, environmental protection, and green city construction provides a broad development space for green finance to a great extent. Cities should broaden the development channels of green finance and build a sound and scientific green financial service system.

## 1. Introduction

The protection and improvement of the ecological environment is a necessary condition for the survival and development of human society and a basic condition to ensure the development of all fields of society. Green finance refers to introducing and implementing the concept of green environmental protection in the development of the financial industry, recognizing and supporting the development and return of environmental protection from a long-term perspective, and building a green city with sustainable development ability. Green finance is a new direction of urban economic development, an important embodiment and measure of environmental protection thought in financial development, and an inevitable trend of urban extensive economic transformation [1]. Therefore, different regions began to actively build an urban green financial system to meet the requirements of economic transformation and ecological and environmental pollution control. However, the economic and environmental conditions of different regions are different, the degree of attention and financial support for environmental protection are also different, and the degree of promoting green ideas in the financial system is bound to be different [2]. How to evaluate the current promotion status of green finance in cities and the balance of green finance among different cities has become the focus of research. The research on the current promotion status of green finance in cities is conducive to restoring the past development and providing important reference information for its future development direction and road.

The BP neural network model has the advantages of adaptability, organization, and self-study ability, and can make an effective, scientific, and reasonable analysis on the promotion status of urban green finance. A genetic algorithm (GA) can solve the problems of local optimal solution in the BP neural network, improve the performance of the neural network, and reduce the error. This paper will introduce the neural network optimized by GA into the evaluation model of the urban green financial development level, evaluate some cities according to the constructed evaluation index system of urban green financial state, and analyze the results accordingly.

The BP neural network model has the advantages of adaptability, organization, and self-study ability, which can effectively, scientifically, and reasonably analyze the promotion status of urban green finance. A genetic algorithm can improve the performance of the BP neural network, avoid the generation of local optimal solution, and increase the accuracy. This paper will introduce the neural network optimized by GA into the evaluation model of the urban green financial development level, evaluates some cities according to the constructed evaluation index of urban green financial state, and analyzes the results accordingly.

## 2. Related Work

Although the evaluation of green finance has been studied internationally, at present, all countries use their own evaluation standards. Generally speaking, the evaluation of green finance focuses on the evaluation of the overall environmental change from the perspective of globalization; Locally, it is to investigate the degree and effect of green responsibility performance of relevant financial institutions, and investigate and analyze the degree of green finance promotion in various countries and regions [3]. Some scholars proposed to make an overall evaluation of the green financial service status of financial institutions in specific regions and the environmental investment status of specific regions, analyze the current situation of green finance in multiple aspects, such as regional conditions, investment level, capital situation, laws and regulations, and put forward corresponding optimization strategies [4, 5].

In China, the promotion path of green finance is still in a period of continuous exploration. Some scholars put forward the inevitability and necessity of promoting green finance according to the economic development situation and development of financial institutions, and concluded through empirical analysis, it is concluded that the promotion status of green finance will largely affect the sustainability of the economic industry [6, 7]. Other scholars pointed out that the current financial reform, the current situation of green transformation of the financial system, and the promotion of incentive policies cannot promote the economy to fully enter the state of benign cycle development. We should independently and actively strengthen the promotion of green finance and stimulate the long-term development potential [8]. Some scholars also believe that green finance is in the most difficult stage of promotion, and suffers some difficulties due to insufficient attention to green finance. In this period, it is necessary to strengthen the support for financial green transformation and capital investment in relevant infrastructure, and encourage low-carbon investment and the development of the green industry from a policy perspective [9, 10].

Some scholars pointed out that banks should pay attention to the strategic role of green finance in the future development, develop and layout their relevant service businesses in advance, and fulfill their social responsibilities while providing commercial services [11]. Other scholars have clarified the relationship between environment and financial development under the framework of green finance and believed that to promote the development of green finance, we must change and break the restrictions of traditional ideas, and carry out the innovation and reform of financial products on the basis of environmental protection [12]. In addition, some scholars have constructed the evaluation system of green finance development at different levels through qualitative and quantitative methods and conducted regional investigation [13]. Other scholars further refined the evaluation system and constructed the evaluation system for subdivided fields, such as green credit and carbon finance [14]. In view of the risk factors existing in the mechanism of financial green development, some scholars have analyzed its utility through the spatial Dobbin model. Some scholars analyze the relationship between regional urban pollution, the economic and industrial structure adjustment, and green finance through regression equation, and reflect that the green transformation of finance is one of the driving forces of industrial structure adjustment through empirical results [15, 16]. At present, based on the research results and experience obtained, China has adjusted and optimized the basic index system of green finance development, built a scientific, fair, sound, and transparent evaluation system and green investment risk assessment system, and promoted the development of green finance projects [17, 18]. In general, the development and promotion of green finance need the joint participation and support of the government and society. In the exploration stage of green finance development, we continue to verify the theory through empirical evidence, find problems, solve problems, and correct problems, so as to speed up the construction of the financial green industry and green city.

## 3. Construction of the Evaluation Model of the Urban Green Financial Development Level

The transformation of economy from an extensive model needs the support of the development of urban financial green industry, which is the embodiment of the demand for environmental pollution control. Although the urban development strategy has always focused on the development of urban financial green industry, the urban industrial structure, the focus of economic development and available resources are different, and the impact on the development of financial green industry is also different. Analyzing the status of green finance in regional cities through a scientific and effective evaluation system is an important basis for promoting the balanced development of financial green industry. At present, the evaluation methods of urban green finance development are mainly analyzed from a qualitative perspective. In order to analyze urban green finance more scientifically and reasonably, this paper will build a test model of the urban green finance development level that can conduct quantitative analysis on the basis of existing theories to analyze the development status of urban green finance [19].

*3.1. Construction of the Evaluation System for the Development Level of Urban Green Finance.* The evaluation index system of the urban green financial development level includes environmental indicators, financial indicators, and social indicators at the standard level. The environmental indicators measure resource energy consumption through capacity energy consumption on the basis of urban green energy conservation and emission reduction measures. Generally, the energy consumption of urban single GDP is selected as the measurement standard. The index to further measure the level of urban environmental pollution is the emission of urban environmental pollutants, that is, the emission of industrial waste gas, wastewater, and solid waste in energy consumption per unit of GDP. Financial indicators measure the effect of local capital allocation in cities. The necessity of capital allocation lies in the scarcity of capital. The scarcity of capital objectively requires people to allocate capital reasonably, that is, when enterprises encounter the restriction of capital scarcity, they should reasonably arrange the capital source structure and use the limited capital to the place where it is most needed. The optimal allocation of capital can optimize the financing structure and the investment structure and improve the yield of capital. Enterprise capital allocation can adopt two ways, such as new administrative allocation and market allocation. Reasonable allocation of financial resources can promote the development of green finance in cities [20]. Resource allocation is measured according to the distribution of loan funds and benefits, which means that the higher the level of resource utilization, the wider the development range of financial green products. The supporting capacity of financial capital is measured by the capital saving rate and the utilization rate of nonlocal investment funds. The ratio between the capital storage rate and the loan rate can measure the degree of support. The increment of urban economic development is affected by the total investment and measured by the marginal capital productivity. Social indicators measure the status of urban green investment and the development level of regional carbon finance. The measurement index of urban green investment is the proportion of investment in environmental protection industry and the proportion of environmental protection expenditure in public utilities. This index can directly reflect the attention of local government and society to the transformation of financial green industry. The development of regional carbon finance reflects the participation of regional enterprises in carbon quota trading. The greater the index value, the better the development of green finance in the cities of the region. In this paper, based on the actual situation and research needs, fifteen indicators are selected and calculated.

The measurement units of different indicators in the constructed index system are different. Before the corresponding data calculation, standardized processing needs to be taken to preprocess the original data, so that the different characteristics of the data can have a unified scale standard. In addition, the calculation of data will be affected by positive and negative indicators, so it also needs to be standardized, as shown in formulas (1) and (2).

Positive indicators are expressed as

$$Z_{ij} = \frac{X_{ij} - \min\left(X_{1j}, \ldots, X_{nj}\right)}{\max\left\{X_{1j}, \ldots, X_{nj}\right\} - \min\left\{X_{1j}, \ldots, X_{nj}\right\}}. \quad (1)$$

Negative indicators are expressed as

$$Z_{ij} = \frac{\max\left(X_{1j}, \ldots, X_{nj}\right) - X_{ij}}{\max\left\{X_{1j}, \ldots, X_{nj}\right\} - \min\left\{X_{1j}, \ldots, X_{nj}\right\}}, \quad (2)$$

where $i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, m$, the number of samples is expressed as $n$, the number of indicators is expressed as $m$, the $j$ $X_{ij}$ refers to the sample index value, and the data after normalization is expressed as $Z_{ij}$.

The weight of each index is calculated by the entropy weight method. As shown in formula 3, it is the calculation of the proportion of $j$ index in the $i$ sample:

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}}. \quad (3)$$

The calculation of entropy is shown as

$$e_j = -k \sum_{i=1}^{n} P_{ij} \mathrm{In}\left(P_{ij}\right), \quad (4)$$

where $j = 1, 2, \ldots, m$, $k = 1/\mathrm{In}(n) \rangle 0$ and $e \geq 0$.

The calculation of information entropy difference value is shown as

$$d_j = 1 - e_j. \quad (5)$$

The weight of evaluation index is calculated as shown in formula 6.

$$w_j = \frac{d_j}{\sum_{j=1}^{m} d_j}. \quad (6)$$

As shown in Figure 1, it is the evaluation index of the development status of urban green finance and its corresponding weight.

*3.2. Construction of Evaluation Model Based on GA Algorithm Optimized Neural Network.* A BP neural network is a multilayer feedforward network with a topological structure and transmitting signals forward through the principle of error inverse propagation. It has three network layers: input, implicit, and output. By virtue of the topological structure, it transmits backward information, and takes the generated error as the basis for weight and threshold adjustment, so as to reduce the error value of a single sample, and the total error is constantly approaching the minimum value. Its calculation formulas are shown in (7) and (8).

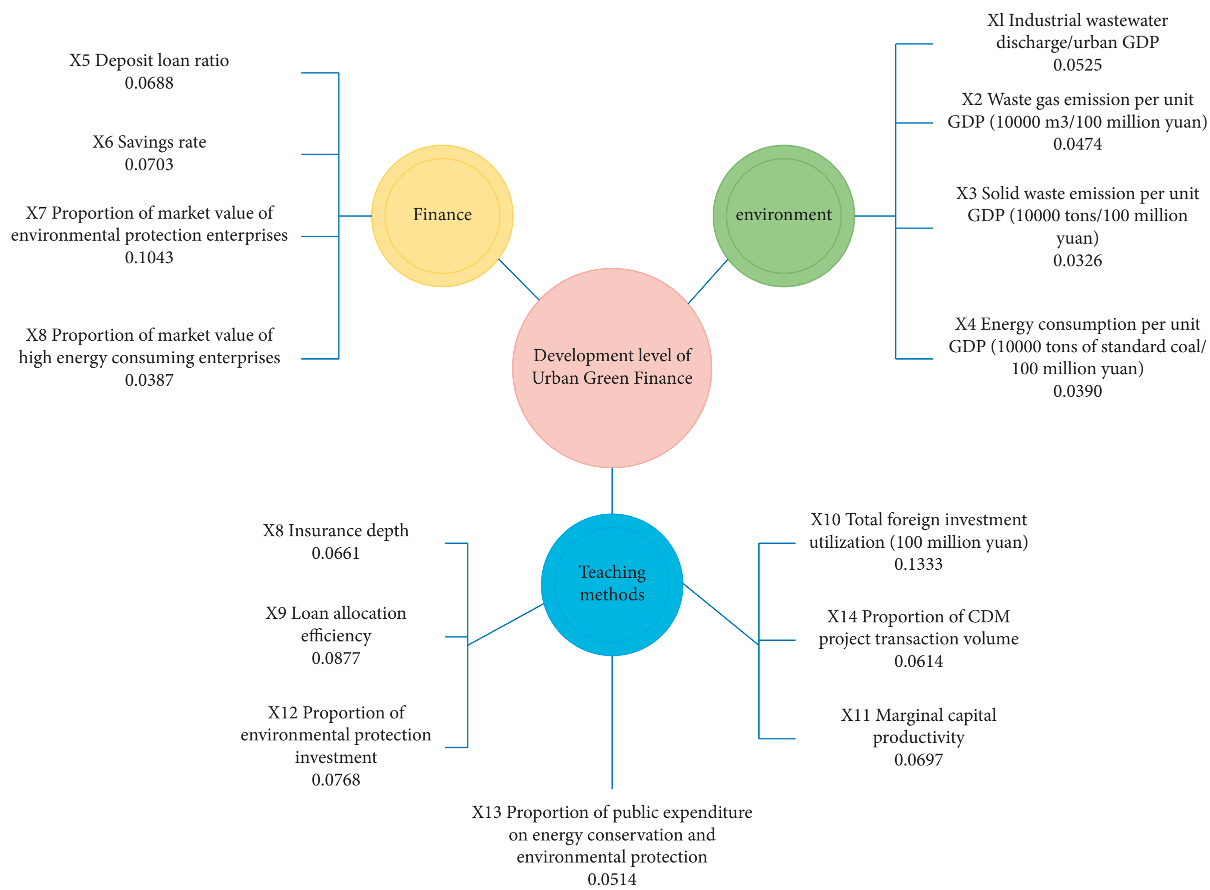


Figure 1: Evaluation index and its corresponding weight of urban green finance development.

$$E_k = \frac{1}{2}\sum_{j=1}^{M}\left(d_j - Y_j\right)^2, \tag{7}$$

$$E = \sum_{k=1}^{K} E_k = \frac{1}{2}\sum_{k=1}^{K}\sum_{j=1}^{M}\left(T_j^k - Y_j^k\right)^2. \tag{8}$$

In the formula, the error of the network training sample is expressed as $E_k$, its output value is expressed as $Y_j$, $M$ refers to the number of output layer units, in which the target value of unit $j$ to the training sample is expressed as $d_j$, and the total network error is expressed as $E$.

To predict the financial development level of green cities through the BP neural network, we need to learn the training samples, store the corresponding weights and thresholds, and then test and compare the numerical results. In this paper, the number of input layer nodes of the BP neural network is the same as the number of evaluation indicators of the urban green development level, that is, 15. The empirical formula of the hidden layer is selected, as shown in

$$H = \frac{a+b}{2}, \tag{9}$$

where $a$ and $b$ represent the number of input and output layers, respectively, so as to determine the number of hidden layers in the empirical formula.

A BP neural network has great randomness in the selection of initial weight and threshold. The increase of training times will affect its gradient decline, so that the convergence speed does not meet the demand. In addition, the BP neural network often produces local optimal solution problems. Therefore, this paper optimizes it through the genetic algorithm, that is, GA, to break the limitation of local optimal solution. GA needs to encode the individual characteristics contained in the population and initialize the population. Then the fitness of individuals in the population is evaluated, and the calculation formula is shown as

$$F = k\left[\sum_{i=1}^{n} abs\left(y_i - d_i\right)\right], \tag{10}$$

where, $F$ represents the degree of individual adaptation, $y_i$ is the individual output, $d_i$ is the target output, $k$ is the parameter, and the output quantity is expressed as $n$.

Then, we select according to formulas (11) and (12):

$$f_i = \frac{k}{F_i}, \tag{11}$$

$$p_i = \frac{f_i}{\sum_{i=1}^{n} f_i}. \tag{12}$$

In the formula, individual fitness is expressed as $F_i$, and the relationship between $f_i$ and it is the reciprocal relationship; $p_i$ stands for the of a selected individual, and the relationship between $f_i$ and it is in direct proportion, that is, the greater the $f_i$ value, the better the individual adaptability, and the greater the probability of being selected.

After selecting outstanding individuals, the new species groups will be crossed, as shown in (13) and (14).

$$a_{ij} = a_{ij}(1-b) + a_{nj}b, \tag{13}$$

$$a_{nj} = a_{nj}(1-b) + a_{ij}b, \tag{14}$$

where $a_{ij}, a_{nj}$ is the individual with excellent gene and $b$ is the parameter.

Finally, the variation is carried out as shown in (15) and (16).

$$a_{ij} = \left\{\begin{array}{ll} a_{ij} + \left(a_{ij} - a_{\max}\right) \times f(g) & r\rangle 0.5 \\ a_{ij} + \left(a_{\min} - a_{ij}\right) \times f(g) & r \le 0.5 \end{array}\right\}, \tag{15}$$

$$f(g) = r\left(1 - \frac{g}{G_{\max}}\right)^2, \tag{16}$$

where $r \in (0,1)$, $g$ refers to the number of iterations completed so far and $G_{\max}$ is the maximum limit of the number of iterations.

A BP neural network optimized based on GA has two advantages as shown in

$$\begin{cases} \min E(w,v,r) = \dfrac{1}{2}\sum_{k=1}^{M}\sum_{i=1}^{n}\left[d_i(t) - y_k(t)\right]^2, \\ s,t\colon w \in R^{m\times p}, v \in R^{n\times p}, \theta \in R^p, r \in R^n. \end{cases} \tag{17}$$

The actual output value of the algorithm is expressed as $y_k$, the learning and training target value is expressed as $d_i(t)$, and the calculation formula of the output mean square error $E$ is shown in

$$y_k(t) = f\left\{\sum_{j=1}^{p} v_{jt} \cdot f\left[\sum_{j=1}^{p} w_{ij} \cdot x_i(t) + \theta_j\right]\right\} + r_t. \tag{18}$$

Figure 2 shows the algorithm block diagram of the BP neural network optimized by the genetic algorithm.

When the model carries out prediction and analysis, its input value is the city index data, and the city score is calculated according to formula 19 as the output target value.

$$S_j = \sum_{i=1}^{n} W_i * \mu_i, \tag{19}$$

where $i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, m$ and $i$ index weights are expressed as $W_i$, and their normalized data are expressed as $\mu_i$.

# 4. Empirical Analysis Results of the Urban Green Finance Development Level Evaluation Model Based on the GA-Optimized Neural Network

*4.1. Test Results of the Evaluation Model Based on the GA-Optimized Neural Network.* This paper selects the provinces and cities in the southern region as the model evaluation object, selects 38 groups for evaluation, randomly selects 32 groups in the training set, and six groups are classified into the prediction test sample set. Twenty-one cities were randomly selected from the training results, and their output results were analyzed. Figure 3 shows the comparison between the training score of the evaluation model and the actual score. The data in the figure shows that the error between the actual score and the training score is relatively large, which indicates that the uncertainty and randomness of the initial weight and threshold have a certain impact on the training results of the neural network, making it easy to produce local optimal solutions and other problems.

The comparison between the training results of the GA based optimization algorithm and the actual urban financial development level is shown in Figure 4. The figure shows that after the optimization of GA, the error between the network training and the actual score is very small, the percentage of the average error reaches 0.5238%, and the maximum error is about three times of the average error, which meets the expectation.

Figure 5 shows the comparison of the error of the BP neural network test results before and after GA optimization. Through the comparison of the results, the optimization of GA effectively reduces the error of the BP neural network prediction model, avoids the problems such as local optimal solution, improves the accuracy of the evaluation model of urban green financial development level, and can provide more accurate data basis for subsequent empirical result analysis.

Figure 6 shows the prediction results of the evaluation model on the development status of financial green industry in six cities. Compared with the actual results, the model prediction results and their relative error remain within a certain range, in which the maximum relative error is within 3%, which meets the expected requirements and can be further tested.

*4.2. Empirical Results of the Urban Green Finance Development Level Evaluation Model Based on the GA- Optimized BP Neural Network.* At this stage, most of the research on green finance in China focuses on qualitative research. And when analyzing the influencing factors, most researchers use the method of starting from consumers or upstream and downstream of the supply chain. Therefore, this paper will conduct quantitative research, focusing on internal and external factors. The internal factors summarized are mainly the income level of residents and innovative talents of green finance, and the external factors are the publicity and education of green finance. Generally, mathematical models are established to analyze the influencing factors of green finance in China, and

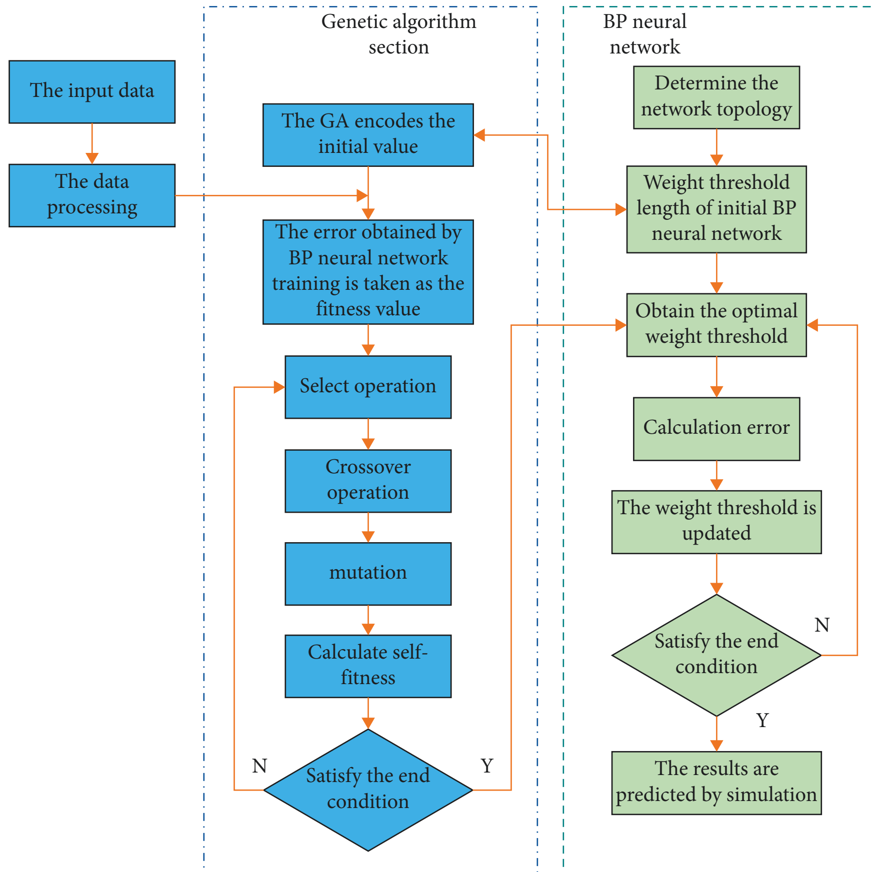


Figure 2: Algorithm block diagram of the BP neural network optimized by the genetic algorithm.

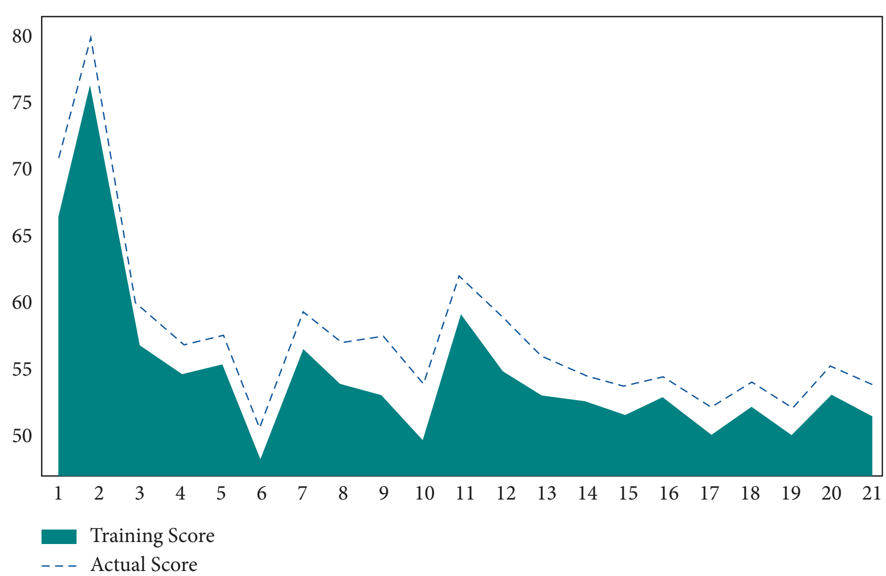


Figure 3: Training and actual score comparison of the urban green finance development level.

reasonable suggestions are put forward according to the influencing factors.

Based on the further analysis of the status of green finance in the cities participating in the experiment, this paper compares the scores of the evaluated cities in 2018 and 2013. The comparison results show that the scores of most cities in the region in terms of the green financial development level have improved to a certain extent. On the whole, in 2013, only a small number of cities in the region had a good state of green economic activities, and the development state of most cities was relatively backward, with an obvious gap. By 2018, more urban financial green industries will have good

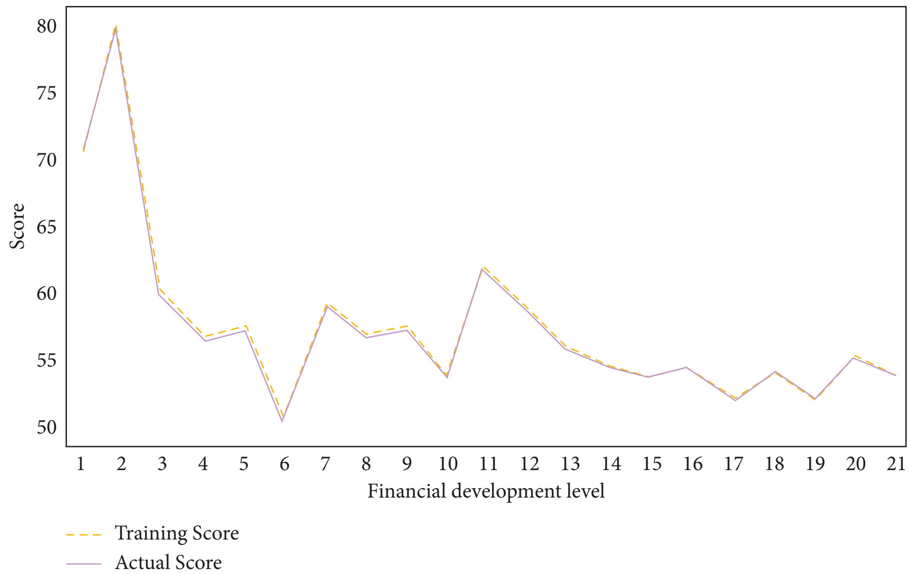


FIGURE 4: Comparison results of training and actual scores of the urban green finance development level evaluation model based on the GA-optimized neural network.

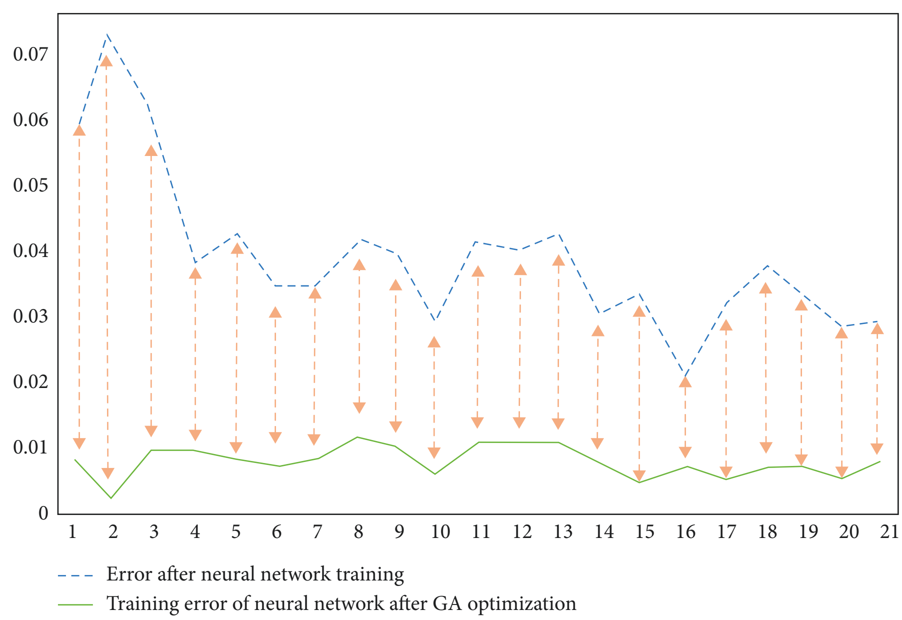


FIGURE 5: Comparison of error of the BP neural network test results before and after GA optimization.

promotion and development space, and the obvious development gap between different cities will gradually narrow. From 2013 to 2018, while vigorously supporting economic activities and industrial development, the region has increased incentive policies for green environmental protection. The interaction between the two has jointly promoted the progress of financial green activities. In addition, in the initial stage of green transformation, urban finance will make funds to concentrate in a city, that is, cities with a better development level of green finance are easier to obtain capital resources, while other cities develop relatively slowly due to the limitation of capital resources. When the overall financial green industry in the region forms a certain scale, it will have a certain diffusion effect, that is, the invested cities with a good development level of green finance will radiate a certain driving role to surrounding cities, and then in turn help promote the overall financial green development process of the region.

In Figure 7, among the cities participating in evaluation, some cities have significantly improved the development of the financial green industry, and the green finance score of some cities has decreased. Therefore, this paper selects two cities from the two cases to compare scoring indicators and the average contribution rate in 2013 and 2018, as shown in Figure 8. The data results show that four indicators that make major contribution to the improvement of the urban

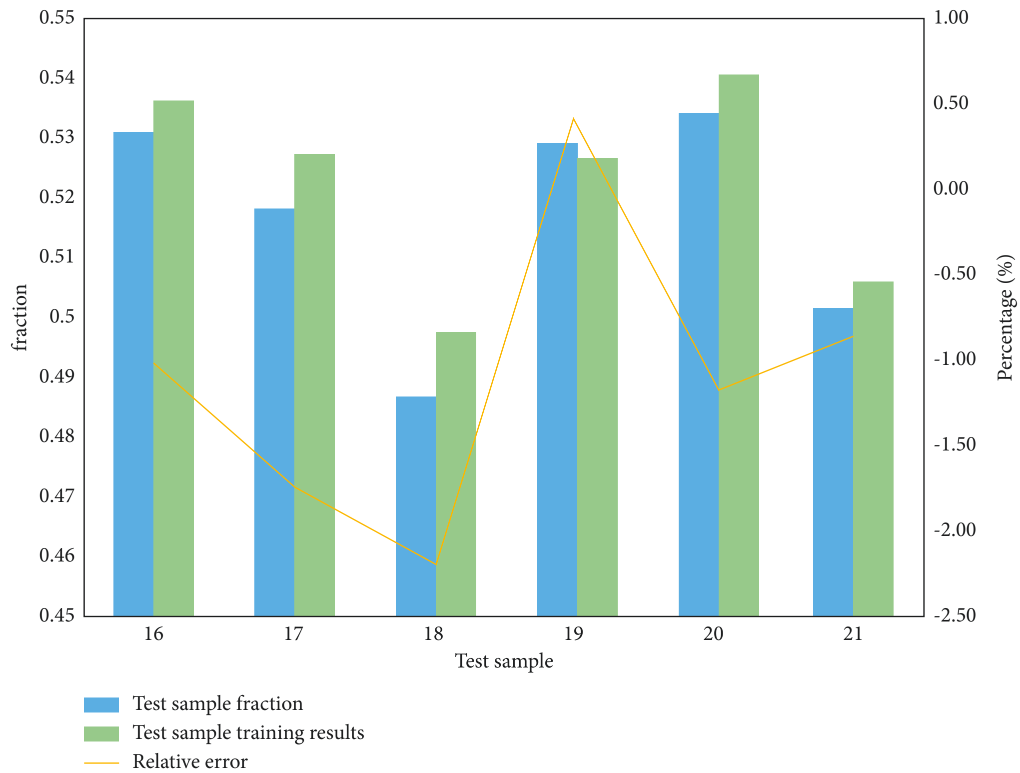


FIGURE 6: Comparison of prediction results of the urban green finance development level evaluation model based on GA-optimized neural network.

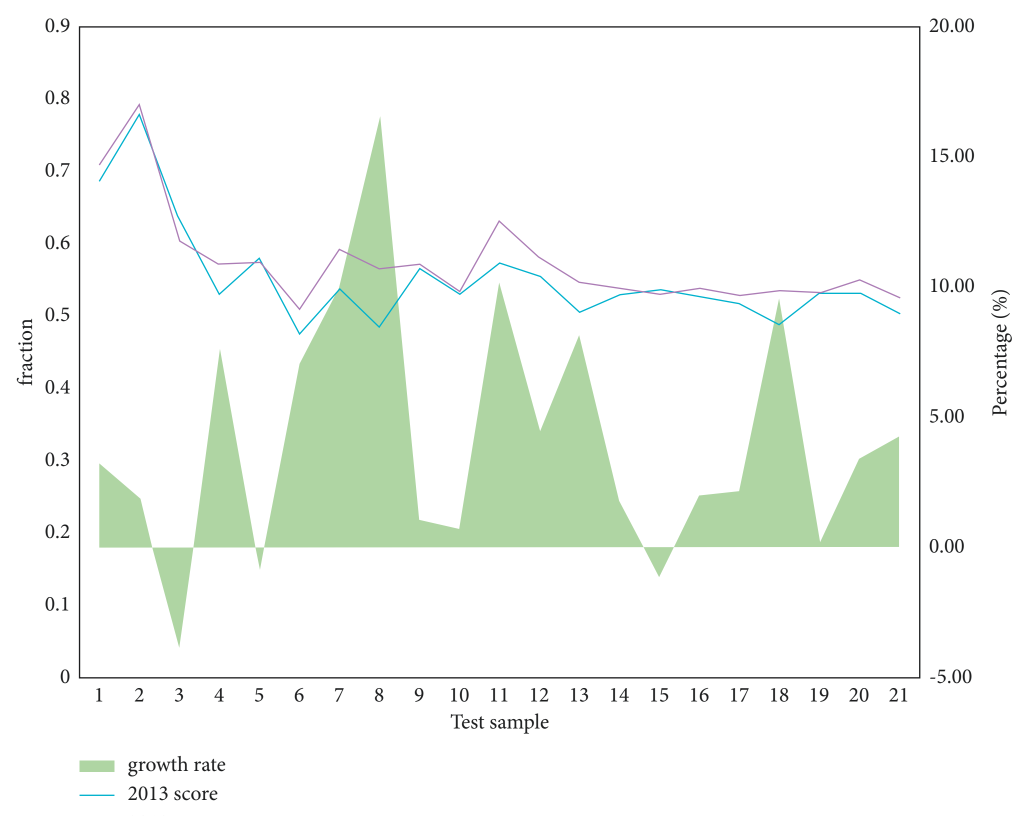


FIGURE 7: Comparison results of the scores of the green finance development level of the evaluated cities in 2013 and 2018.

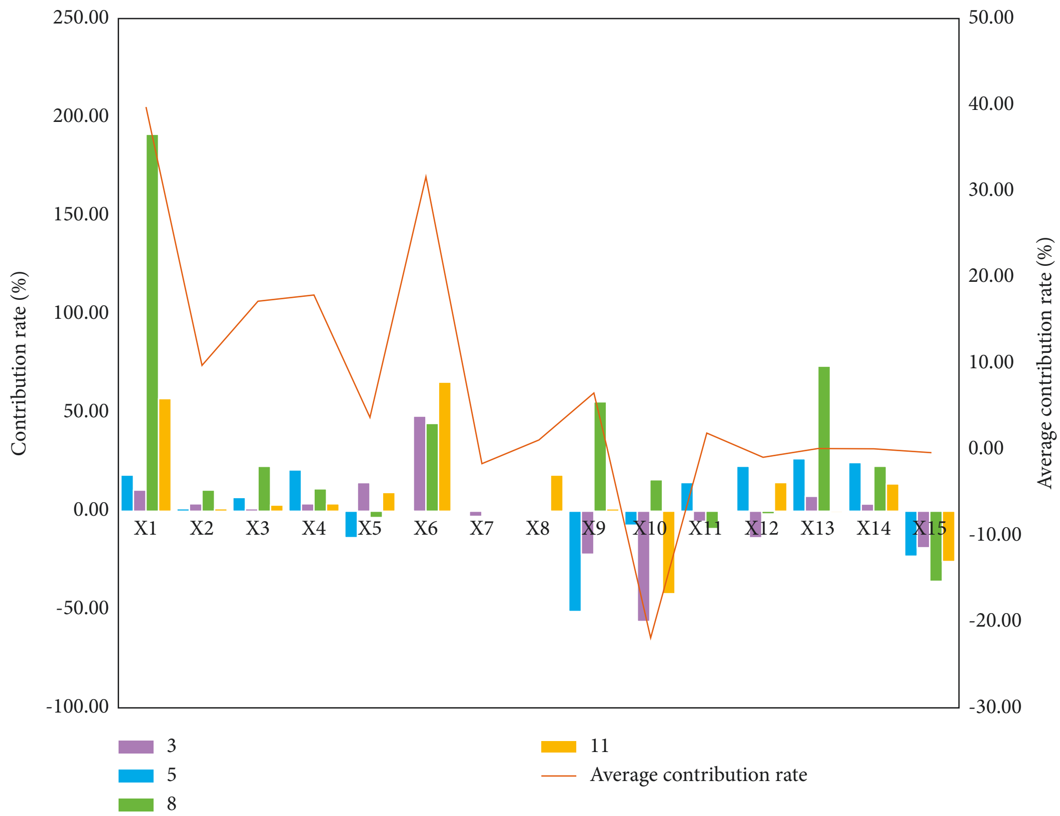


Figure 8: Comparison results of evaluation indicators and the average contribution rate of green finance development in evaluation cities in 2013 and 2018.

financial development level are industrial wastewater, solid waste discharge, total energy consumption, and insurance depth. This shows that the region's policies on environmental protection and energy conservation are relatively perfect, attaches importance to the restrictions on high energy consuming enterprises, and expand the promotion channels of green insurance products. The data show that the four main indicators that can contribute to the improvement of city financial development are industrial waste, solid waste emissions, total energy consumption, and insurance depth. The growth rate of urban green finance in cities 8 and 11 is obvious. The growth reason of city 8 mainly comes from its deposit loan ratio, savings rate, and the proportion of environmental protection investment, which shows that it not only develops rapidly in finance, but also strongly supports the development of environmental protection industry and provides a good development space for it. The growth of the green financial development score of city 11 mainly comes from the public share of environmental protection expenditure and the share of enterprise market value, which indicates that the urban green environmental protection industry has developed well, and environmental protection enterprises are given sufficient support in terms of policy and development space, so as to achieve phased results in the green transformation of enterprises.

The state of green finance in cities 3 and 5 has declined. Excluding the last indicator, the main reason for the decline of the state of city 3 comes from the change of the proportion of environmental protection investment in investment and the distribution of loan funds. The investment growth of the environmental protection industry in the city does not match the economic growth, and the slow growth of investment restricts the green transformation and development of enterprises. The reduction of the contribution rate of loan allocation efficiency indicates that the financial activity of the city is reduced, which inhibits the growth of financial green industry. The problem of city 5 is that its financial support for green environmental protection is small, and the development potential of environmental protection industry is limited.

## 5. Conclusion

In this paper, the neural network and the genetic optimization algorithm are introduced into the evaluation model of the urban green financial development level, and corresponding evaluation indexes are selected according to the actual needs. Experiments show that genetic algorithm optimization can improve the performance stability and prediction accuracy of the neural network evaluation model. Through the evaluation of the evaluation model of urban green finance development level in this paper, we can see that the overall development level of green finance in the evaluation area is gradually improving. However, there are still some deficiencies in this paper. Economic transformation is an inevitable way to protect the environment.

Green finance is not only the inevitable result of economic transformation, but also the need of environmental protection and economic development. The study did not consider the difference between economic development and green environment. This difference will affect the development space of the financial green industry, and the development between regions is due to lack of balance.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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