

Research Article

Risk Management Analysis of Modern Commercial Banks Using Behavioral Finance Theory and Artificial Neural Networks

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With the increasing trend of economic globalization, China's pace of promoting interest rate marketization is gradually accelerating, and financial market volatility is increasing day by day. Credit risk is at an all-time high for commercial banks. The most significant risk that banks face is credit risk. The methods and technologies of commercial bank risk management have improved with the accelerating process of financial globalization, but the rationality of risk managers who implement daily management is limited and will be influenced by emotion and will. As a result, they will be unable to implement completely unbiased risk management, i.e., they will not be able to apply risk management objectives to daily risk management in an optimal manner. The importance and measurement complexity of commercial bank credit risk is growing in tandem with the financial market's increasing complexity. The traditional credit risk assessment model is no longer adequate to meet the requirements of today's financial risk management system. The research into the credit risk assessment model is both theoretically and practically significant.

1. Introduction

Commercial banks' credit risk refers to the risk of economic losses resulting from customers' failure to fulfill their contractual obligations, i.e., the possibility of borrowers failing to repay bank loans in full and on time for a variety of reasons [1]. The financial industry is one of the international industries classified according to international standards, the core of modern economy, a key industry in national economies, and even the lifeblood of national economies [2]. Commercial bank credit risk assessment is relatively mature in Western developed countries, with a corresponding system in both practice and theory. In China, however, credit risk assessment research has only recently begun, and it is still in the early stages of traditional proportional analysis, which falls short of meeting the needs of commercial banks in terms of credit risk prevention and control [3]. The connotation of risk management in commercial banks has been continuously enriched, and management methods and technologies have been continuously improved, but risk

management is ultimately about people, not systems or machines, which leads to a slight deviation between the implementation and effect of daily risk management and the original assumption [4]. Only through the scientific and accurate evaluation of the credit risk of enterprise customers of commercial banks can we better provide the basis for their loan decision-making and facilitate commercial banks to control the credit risk more effectively. With the deepening reform of China's commercial institutions, commercial banks have become the mainstay of the international economic and financial system. China's banking industry will take the construction of enterprise credit evaluation mechanism suitable for China's national conditions and scientific judgment of enterprise credit rating as an important work to guide loan decision-making and enhance the ability of risk early warning and control [5]. Under the background of constantly changing financial environment and increasingly innovative financial instruments, the stable, safe, and healthy development needs of commercial banks require them to devote themselves to building a healthy and

dynamic internal control system operation mechanism, which objectively requires commercial banks to constantly improve the internal control mechanism and fundamentally establish a long-term and effective risk management system.

With the development of the computational intelligence, artificial intelligence [6] has come into the public eye and is well known to ordinary people. Big data [7] is often associated with the Internet industry, but in fact, big data has existed for a long time. Facing the challenge of international banking, China's commercial banks should use scientific and reasonable risk management tools and means to resist risks, and pursue the promotion of bank value to the greatest extent on the basis of controlling the bank's risk level. As the main risk of commercial banks, the management of credit risk has a special position. Commercial banks use modern financial tools and technologies to predict, supervise, and control the possibility and uncertainty of debtor default in the credit granting process, in order to minimize possible credit losses or maximize extra credit gains, which primarily consists of the identification, evaluation (measurement), monitoring, reporting, and control of credit risks [8]. Data mining technology has become increasingly popular in the financial sector, resulting in an uptick in academic research on the use of data mining technology in credit risk assessment [9]. The neural network algorithm (BP-ANN) is one of the most promising methods in data mining technology as a new technical means and method; support vector machine has been extensively studied. Scholars have used vector machines to evaluate banks' internal credit and have made a significant breakthrough that not only lowers our credit risk but also protects the public. Internet enterprises have amassed rich big data as a result of the development of Internet platforms such as online social networking platforms, Internet platforms, and e-commerce platforms. Cleaning these massive online data can make these data valuable and operable [10]. Digitization can not only develop the clues of product innovation in time but also make use of the huge profits brought by the mobility of data to Internet enterprises. This model also has a profound impact and impact on traditional financial enterprises [11].

Making full use of the public information of enterprises and establishing a credit risk assessment model are of great practical significance for commercial banks to improve their profitability and reduce the rate of non-performing loans. Banks face all kinds of financial risks all the time in the process of operation, among which credit risk occupies a special and important position [12]. At present, China has not established its own credit risk measurement model, which is based on its own supervisor's judgment and cannot make objective evaluation, so credit assets cannot be quantitatively priced or traded. At present, China's commercial bank outlets are all over the country, covering a wide range [13]. With the changes of the times, many commercial banks are also based on the Internet, e-commerce, and online banking, but the market risks are obviously increasing [14]. Scientific and accurate credit risk assessment of commercial banks' corporate customers is an important step toward improving commercial banks' risk identification, early warning, and control capabilities, as well as the foundation for

fundamentally eliminating the impact of nonperforming loans. However, China's banking business has been too centralized for a long time, and credit assets account for a large proportion of bank assets. The most important thing that commercial banks can do to improve their ability to deal with risks and management is to improve their credit risk assessment level. In this paper, the modern Chinese banking system will be divided and modeled in conjunction with financial theory to improve credit risk, and BP-ANN, vector machine, and other algorithms will be introduced to provide an innovative method of independent research and development for China's commercial banks to measure credit risk.

2. Literature Review

Many credit risk measurement models are presented in the literature [15], which are not only advanced in theory but also have a high practical application value. They produce fruitful results in terms of both breadth and depth, and they serve as an ideological and theoretical reference for commercial bank credit risk measurement research in China. Credit risk is described as a nonlinear complex system in the literature [16]. To deal with many interacting and influencing factor values, modern credit risk assessment requires advanced computer science and technology as well as mathematical modeling knowledge. Literature [17] is a branch of finance that studies how people make financial decisions from a psychological standpoint. It believes that people's rationality is limited, that cognition and judgment are limited, and that their actions will be influenced by their own psychological activities. Literature [18] employs an Internet-based customer information tracking system to track and predict customer development trends, to extract as much customer information and potential value as possible, and to use this data to make investment decisions. In literature [19], in order to overcome the shortcomings of traditional empirical analysis methods, such as a lack of quantitative evaluation and a limited ability to conduct comprehensive analysis, western scholars began to look for mathematical methods to solve the problem of quantitative credit risk evaluation. In literature [20], there are many risk quantification models in traditional risk management theory, such as loan portfolio dynamic optimization model and loan portfolio risk measurement model. Big data technology is not restricted by it, and massive unstructured data can also be processed. In literature [21], only by formulating strategies to meet market demand and adapt to environmental changes can banks improve their competitiveness and value creation level and provide strong support for the long-term development of enterprises. In this way, when banks are facing various challenges, they can make scientific and appropriate strategic decisions and deployment in time and take reasonable control measures, so as to effectively resolve the crisis. The research in literature [22] shows that a standardized, transparent, and systematic internal control system is not only an effective guarantee for the steady operation of commercial banks in the process of seeking profit maximization but also a fundamental measure to protect the interests of depositors, maximize shareholder value, ensure the high-speed and safe

operation of the financial market system and the sustainable and healthy development of the national economy. Literature [23] proposes to establish a BP-ANN model of credit risk for different industries according to industry classification. The enterprises are subdivided into industrial enterprises, commercial enterprises, construction and installation enterprises, public utilities, and other industries. Taking industrial enterprises as an example, they are specifically divided into two evaluation modes: large and medium-sized industrial enterprises and small industrial enterprises. The initialization under each mode is more accurate than the traditional risk evaluation and plays an important role in loan decision-making. Literature [24] uses the investment decision support and risk control system integrating computer network technology, modern analysis methods, and advanced decision-making models to make investment decisions, quantify, and quantitatively analyze various influencing factors, so as to obtain the decision of whether to invest, realize the real-time processing and online service of bank credit and investment business, and make the effectiveness of investment decisions. Rationality, scientificity, and accuracy have been greatly improved.

To summarize, it can reflect the current situation of China's commercial banks, which rely heavily on data modeling to assess the risk of confidence. How to ensure the safety of commercial banks' own assets and improve the quality of credit assets is the basis of their survival and development in the face of increasingly fierce horizontal competition at home and abroad, as well as increasing market risk. Scholars have also made significant contributions to the breadth and depth of credit risk analysis. Build a relatively comprehensive and reasonable evaluation index system on this foundation to lay the theoretical foundation for commercial bank credit risk evaluation. The introduction of big data into commercial bank risk management has been agreed upon, and big data will become a significant development and transformation opportunity for commercial banks. Domestic research began only recently. Even though I have research experience from a variety of universities, it does not fit in with my commercial bank. The findings of the study are not backed up by reliable data. It is necessary to improve dynamic, overall, and multifactor comprehensive research.

3. Overview of Credit Risk Assessment

3.1. Credit Risk Implications. Credit risk is the oldest kind of risk in the financial market. The concept of credit risk has been continuously improved in the process of social progress and the continuous improvement of financial market [25]. The daily implementation of risk management includes finding the focus of risk and then using quantitative and qualitative analysis methods to evaluate the degree of risk through investigation, measurement, calculation, analysis, and prediction, so as to guide the business operation. In the process of business operation and management, due to the influence of various unpredictable uncertain factors, the actual income of bank credit funds deviates from the expected income, so that the bank is likely to suffer losses.

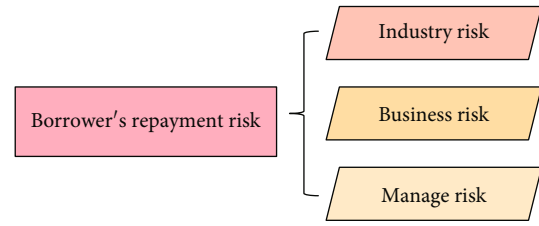


FIGURE 1: Classification of lender influencing factors.

It takes trust as the premise. The credit grantor's trust in the trustee comes from the sense of security of the trust relationship, depends on the credit level of the trustee, and depends on the rational judgment of the credit grantor. This kind of credit from the perspective of social psychology emphasizes moral binding force. Due to the factors of risk management personnel, there may be a gap between the daily implementation behavior of risk management and the most efficient, reasonable, and scientific behavior, which may lead to the deviation of the implementation result from the ideal state. Credit risk can be divided into broad sense and narrow sense. The broad sense of credit risk refers to the uncertainty or volatility of the influence of various uncertain factors on commercial banks in the future, mainly including the volatility or uncertainty of future earnings or asset values, which makes the actual earnings of banks deviate from the expected earnings, suffer losses, or obtain additional earnings. In a broad sense, credit risk not only includes default risk but also includes the possibility that the off-balance-sheet contingent liabilities of commercial banks will turn into on-balance-sheet liabilities due to the change of the debtor's performance ability and credit rating status, which will change the value of credit assets. However, in the narrow sense of credit risk, there are many aspects that lead to losses of banks. Classification of influencing factors of lenders is shown in Figure 1.

First, the of credit risk is asymmetric, that is, the uncertainty of credit fund security caused by the joint action of subjective reasons and objective conditions of the debtor, that is, the possibility of bad debts formed by credit funds. Usually, this loss is far greater than the interest income brought by the performance and repayment of loans by enterprises. The fluctuation of market price and the resulting investment income are centered on their expectations. There are many reasons for credit risk. From natural disasters to changes in political and economic situation at home and abroad and the moral quality of borrowers and lenders will affect the repayment of bank loans. Western commercial banks define credit risk as follows

$$R = f(I, E). \quad (1)$$

Among them, R is credit risk, work is internal factor, and E is external factor, that is, credit risk is a function of internal and external factors. The small probability event of enterprise default and the asymmetry of loan income and loss lead to the deviation of the distribution curve of credit risk income. The probability density of extreme value in loss

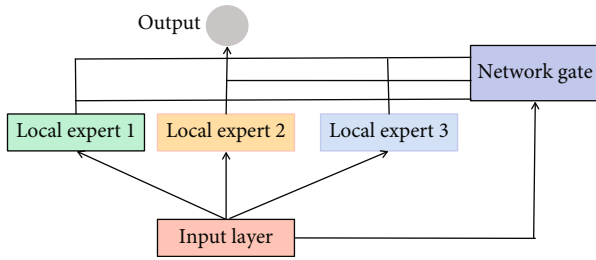


FIGURE 2: Neural network mode.

area is larger than the corresponding normal distribution probability density curve, which makes the distribution of credit risk asymmetric, that is, the so-called “fat tail” problem.

Second, credit risk is a complex nonlinear system. Risk managers’ attention is sometimes focused on recent inter-bank events and risks raised by senior management or the media, rather than on the investigation, analysis, or performance of risk indicators, in the daily implementation of risk management. This focus on judgment can sometimes help with current risk management. The outcome of the evaluation will be influenced by a number of factors. Before correlation, credit risk is not normally distributed, and it is highly infectious. It may have little to do with the bank where the risk managers are stationed, and focusing on it is pointless. On the contrary, it will squander manpower and time while ignoring the detection and management of real threats. The credit scoring model can be expanded by using nonlinear discriminant analysis and the BP-ANN method. BP-ANN is a parallel distributed pattern processing system based on neuropsychology and cognitive science research findings. The structure of BP-ANN is composed of an input layer, several intermediate hidden layers, and an output layer. It has the ability of self-adaptation, self-organization, and self-learning similar to the human brain and has successfully solved many thorny problems in the fields of pattern recognition, combination optimization, prediction, and so on, showing good intelligent characteristics. The neural network model is shown in Figure 2.

Credit risk is transitive and cumulative. The formation of “credit risk chain” cannot be separated from the transferability of credit risk, because in financial transactions, the credit risk of one party may lead to the credit risk of the other party, and the credit risk of the other party may lead to the credit risk of other counterparties handed over to it, and thus the “credit risk chain” is formed. As the central link in the whole credit chain, the influence of credit risk on banks will have a destructive effect on the payment system and will have an impact on the economy on a broader level, which may lead to the collapse of the whole financial system due to the domino effect, thus leading to the emergence of the financial crisis. It is precisely because of this transmission characteristic of credit risk that the credit risk is constantly spreading and related, which leads to the rapid increase of the total credit risk, which is also a potential source of the credit crisis and even the financial crisis.

Finally, it is difficult to obtain credit risk data. Now the data of each enterprise, as well as the development process,

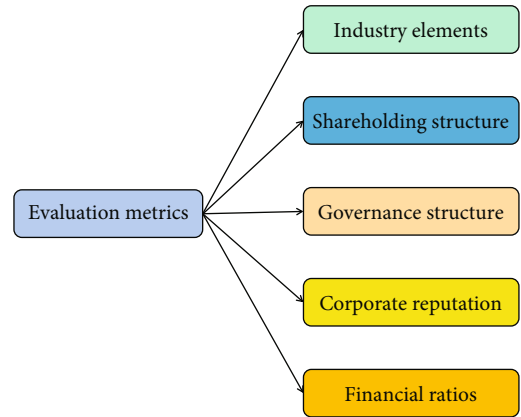


FIGURE 3: Credit risk indicators of commercial banks.

and the internal system are different. Massive data has exceeded the processing capacity of common typical databases or software and hardware environments. The traditional risk system is difficult to support a large amount of data, memory screening, and classification processing, resulting in a large number of data being abandoned, and people cannot use accurate data to make decisions, which leads to the serious lag of our secondary market behind the market risk research.

To sum up, the risks of commercial banks are generated with the development of information bank credit business and cannot be eliminated objectively. Although credit management is difficult, we should also face up to this problem and transform the risks into data through continuous efforts and a series of modeling methods such as data mining modeling, so that people can intuitively face these problems and solve these problems, better serve the public.

3.2. Overview of Credit Risk Assessment of Commercial Banks. Credit risk assessment refers to a comprehensive evaluation process in which risk managers conduct comprehensive and systematic analysis and research on their statistical data, risk information, and nature by studying and analyzing the types and causes of credit risk and using a series of evaluation indicators and evaluation methods before the occurrence of credit risk, so as to determine the frequency and intensity of various risks. It provides a reference basis for further selecting appropriate risk treatment methods. Commercial banks apply certain technologies to conduct qualitative analysis and quantitative calculation on the factors that may cause loan risk, so as to measure the loss of loan funds and provide basis for loan decision-making. The credit risk indicators of commercial banks are shown in Figure 3.

At present, there are not only relatively simple qualitative methods but also quantitative methods with solid diagnosis foundation and complex mathematical structure. Credit risk assessment is the most critical link in the whole process of credit risk management. The error of credit risk assessment will lead to the improper selection of credit risk management methods and then lead to the failure of credit

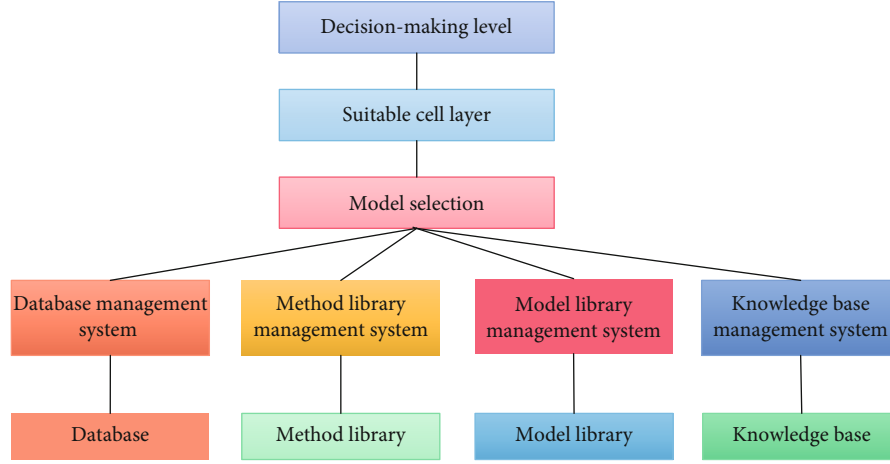


FIGURE 4: Data management structure.

risk management. The data management structure is shown in Figure 4.

Modern credit risk assessment needs the help of advanced computer science and technology and mathematical modeling knowledge to deal with many factors that interact and influence each other. It is a research field that needs cross-disciplinary cooperation and continuous development and innovation. This paper uses vector machine to calculate it. First, it is optimized by using Lagrange method, as shown in the following formula.

$$L(x, \alpha) = f(x) + \sum_{i=1}^{p+q} \alpha_i c_i(x) = f(x) + \alpha^T c(x). \quad (2)$$

Among them, $\alpha = (\alpha_1, \dots, \alpha_{p+q})$, $c(x) = (c_1(x), \dots, c_{p+q}(x))^T$, p inequality constraints, and q equations constraint.

Let the function $f(x)$, $c_i(x)$, $i = 1, \dots, p + q$ have a continuous first-order partial derivative, and x^* is the local solution of the problem. If the gradient vector x^* of the effective constraint at $\nabla c_i(x^*)$ is linearly independent, or all constraint functions are linear functions, there is a vector $\alpha^* = (\alpha^*, \dots, \alpha_{p+q}^*)^T$ of $p + q$ dimension, so that

$$\begin{aligned} \nabla_x L(x^*, \alpha^*) &= \nabla f(x^*) + \sum_{i=1}^{p+q} \alpha_i^* \nabla c_i(x^*) \\ &= \nabla f(x^*) + \nabla c_i(x^*) \alpha^* = 0, \end{aligned} \quad (3)$$

$$c_i(x^*) \leq 0, i = 1, \dots, p, \quad (4)$$

$$c_i(x^*) \leq 0, i = p + 1, \dots, p + q, \quad (5)$$

$$\alpha^* \geq 0, i = 1, \dots, p, \quad (6)$$

$$\alpha_i^* c_i(x^*) = 0, i = 1, \dots, p. \quad (7)$$

The above conditions are called KKT conditions. KKT condition is a necessary condition for solving constraint problems. The $p + q$ dimension vector α^* is called Lagrange multiplier vector, and its component is called Lagrange mul-

tiplier. Optimization method is an important theory of classification problem support vector machine. The kernel function technique of vector machine can be used to evaluate the credit risk of commercial banks. It can better realize multidimensional data classification. This model has strong generalization ability and can meet the needs of credit rating research. It is one of the important methods to study information risk at present.

4. Empirical Research

The number of large commercial banks and joint-stock commercial banks in China has remained the same in recent years, the number of urban commercial banks has changed slightly, and the number of rural commercial banks has increased sharply. The rate of nonperforming loans has decreased year by year, and the control ability of nonperforming loans of large state-owned banks needs to be strengthened. Loans are divided into five categories: normal, concerned, subordinated, suspicious, and loss. The first two categories belong to normal loans, and the last three categories are non-performing loans. Commercial banks have largely lightened the burden and heavy burden of history. With the rapid economic growth, China's loan business continues to grow, and the ability of bank asset structure is also strengthening. However, there are still many large commercial banks that are not cautious in the operation of the system, resulting in higher nonperforming loans than joint-stock commercial banks, and are not smart enough to respond to market changes. As shown in the figure below, the change of nonperforming loans of commercial banks is shown in Figure 5.

Whether at home or abroad, the bad debt and default data of commercial banks are trade secrets, so it is difficult for researchers to directly obtain the data of actual defaulting companies. For the unconventional work of risk management, there is no fixed routine to follow, so it costs more time and manpower. However, after time and economic development, the original financial system has become a shackle of economic development under the new normal. Through calculation, it can directly reflect the size of the

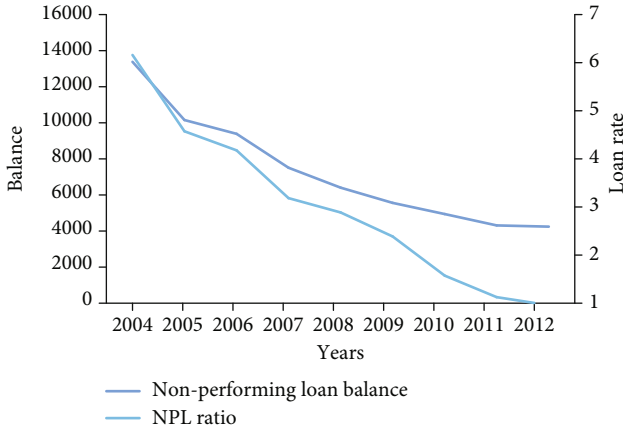


FIGURE 5: Changes in nonperforming loans of commercial banks.

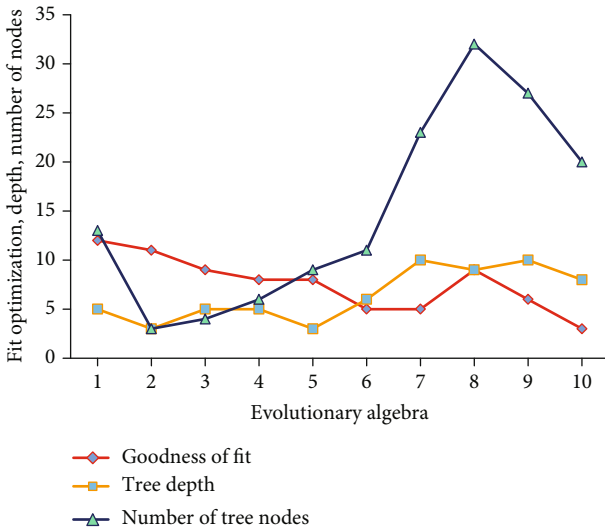


FIGURE 6: Dynamic changes of goodness of fit, number of layers, and nodes of structure tree with BP-ANN algorithm.

bank's value creation ability, improve its risk management level, and improve the bank's value creation ability. Due to the introduction of BP-ANN algorithm, the process of program simulation is also the experimental process of credit evaluation model construction and solution. Combined with the dynamic changes of goodness of fit, the number of layers and nodes of structural tree with BP-ANN algorithm is as shown in Figure 6.

Figure 6 shows how the goodness of fit improves as BP-ANN is increased, and the current optimal individual information is recorded. To determine the best network structure, the network is trained for seven different hidden layer nodes. After many simulation tests, the BP-ANN model has the smallest error when the number of hidden layer nodes is 7, after 300 times of network iterative operation. The final selected network learning rate LR is 0.05, with a variable step expansion coefficient LR Inc. of 1.05, a variable step size reduction coefficient LR Dec of 0.7, and a momentum factor of 0.95 after repeated debugging. Figure 7 depicts the BP-ANN training error curve.

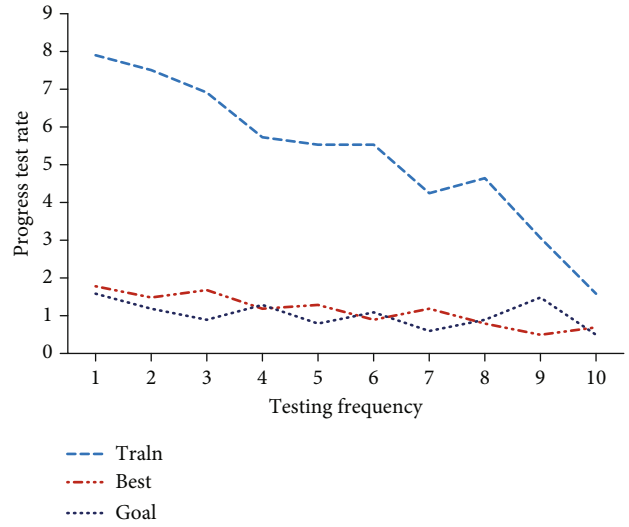


FIGURE 7: BP-ANN training error curve.

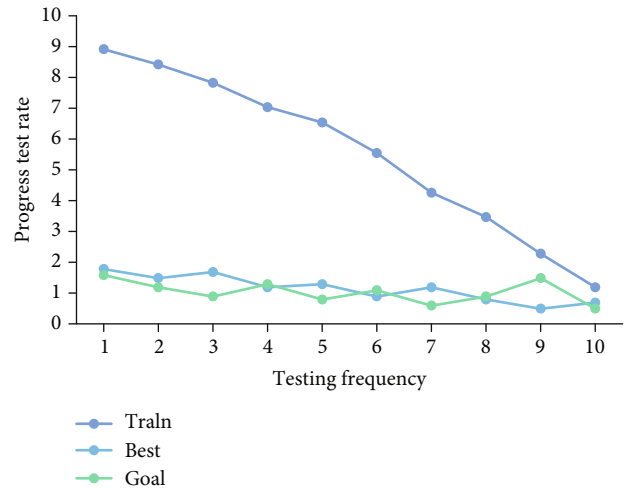


FIGURE 8: Simulation test results of the input variables of the sim function network.

The above Figure 7 uses 7 hidden points to test the network and builds a three-layer BP-ANNBP-ANN model. Since the BP-ANN network adopts the error back-propagation algorithm, it is essentially an unconstrained nonlinear optimization calculation process. When the network structure is large, the calculation time is long, and it is easy to be limited to the local minimum point. To simulate the trained BP-ANN, usually call the input variables of the sim function network in the BP-ANN toolbox for simulation testing, as shown in Figure 8.

Finally, I substitute 15 training sample values as input variables into the structural operation of the optimal individual. The theoretical solution of the credit risk measurement standard and the fitting diagram of the observed values are shown in Figure 9.

Figure 9 The evaluation model basically reflects the change of credit security. Through the above simulation test, it can be seen that the application of BP-ANN algorithm and

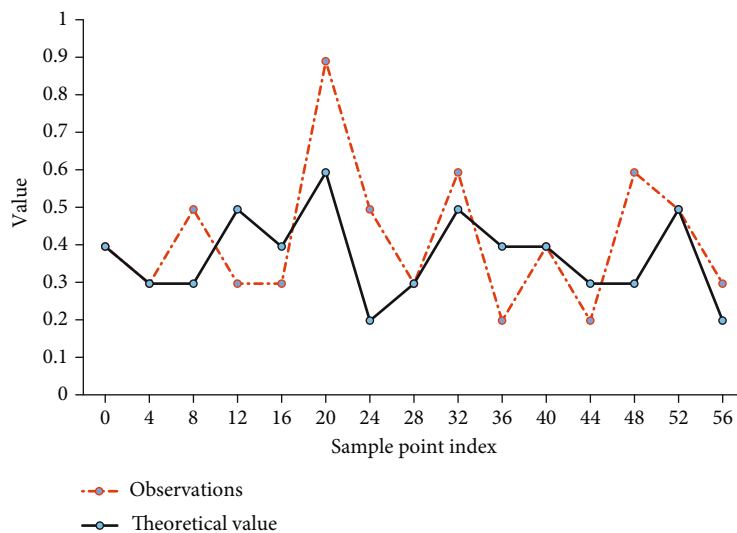


FIGURE 9: Training sample you and renderings.

vector machine can reduce the credit risk rate of commercial banks, more clearly reflect the feasibility and good judgment results of the model, and have high practical value. The model provides a prediction basis for commercial banks to make the decision of whether to lend or not, so as to reduce the risk.

5. Conclusion

As economic globalization continues to deepen, businesses face increasingly fierce competition, making it more difficult to accurately assess credit risk. Commercial banks are becoming increasingly interested in developing a scientific and practical credit risk assessment model. Based on theoretical analysis, we can see that commercial banks' risk management has a significant impact on their ability to create value, primarily in five areas: nonperforming loan ratio, provision coverage ratio, loan-to-deposit ratio, asset-liability ratio, asset-liability ratio, and capital adequacy ratio. China's commercial banks, on the other hand, have not yet fully achieved standardized and compliant internal control management due to development and internal control management limitations. The majority of the research findings are used to examine the mechanism of commercial bank credit risk formation in China from the perspective of macropolicy management, or to examine the process of commercial bank risk formation from the perspective of system and institutional changes. There are few studies on commercial bank risk management from a financial perspective to establish a systematic management system. Based on financial theory, this paper investigates the drawbacks of commercial bank development and the current state of information risks and proposes the BP-ANN and vector machine algorithms for data classification, which improve classification accuracy and give credit risk assessment a new lease on life. Finance research and development have a significant impact on information development. Due to a time constraint, the

research presented in this paper is not exhaustive; however, we will continue to research this topic in the future.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors do not have any possible conflicts of interest.

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