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PERFORMANCE EVALUATION MODEL OF CORPORATE FINANCIAL SUSTAINABILITY BASED ON SWARM ALGORITHM

LINGJIE CHANG*

Abstract. In traditional financial performance evaluation models, parameter settings are often too large or too small, resulting in significant model errors. To address this issue, an improved artificial bee colony algorithm was proposed and applied to optimize the parameters of performance evaluation models. This method first constructs a corporate financial performance evaluation system, and then improves the artificial bee colony algorithm with differential evolution algorithm to optimize the parameters of the long short-term memory network, in order to improve the accuracy of the long short-term memory network in corporate financial performance evaluation. The results showed that the improvement of the ABC algorithm was effective. The improved ABC algorithm converged on the Ackley function in the 800th iteration, and the ABC algorithm converged in the 1400th iteration. The evaluation error of the proposed method is the lowest, with the algorithm having the lowest four errors of -0.0121, 0.0453, 0.0683, and 0.0047, respectively. Among the other algorithms, the comprehensive error of the financial performance evaluation model based on Long Short Term Memory (LSTM) network is relatively low, but still lower than the algorithm proposed in the study. The research proposes a long short-term memory network optimized based on improved artificial bee colony algorithm, which can accurately evaluate the financial performance of enterprises, help them review their own development level, and clarify their future development direction.

Key words: ABC; Central solution idea; Dynamic adjustment factor; Financial performance evaluation; Lstm

1. Introduction. In the current fierce market competition and constantly changing financial environment, the sustainable development of corporate finance has become a focus of attention for company managers, investors, and policy makers. Financial sustainable development refers to the ability of enterprises to maintain financial health and growth potential in the long term, effectively respond to uncertain market risks, and continuously create value for shareholders. However, how to quantitatively evaluate the financial performance of enterprises and achieve sustainable development on this basis is a complex and thorny issue that requires the comprehensive application of various theories and methods. Faced with the increasingly complex financial data and operational environment of enterprises, existing performance evaluation models often struggle to capture the nonlinear relationships and dynamic characteristics in the decision-making process, making it more difficult to effectively evaluate the long-term financial sustainability of enterprises. The research aims to develop a performance evaluation model for sustainable financial development of enterprises based on bee colony algorithm. By imitating the foraging behavior of bees in nature through intelligent algorithms, the evaluation process of financial performance is optimized, and the accuracy and adaptability of the evaluation model are improved.

Innovatively applying the bee colony algorithm to performance evaluation in the financial field, utilizing its outstanding performance in optimization problems to deeply mine and intelligently analyze enterprise financial data. Research can not only provide a new and more predictive financial performance evaluation tool for enterprise management, but also provide a scientific decision support system for investors and regulatory agencies, thereby promoting long-term and sustainable financial development of enterprises. The study will conduct research on enterprise performance evaluation from four aspects. Firstly, a review of the current research status of performance evaluation models and bee colony algorithms will be conducted; Secondly, the construction of a financial evaluation model based on the bee colony algorithm; The third is experimental analysis of the feasibility of the model; Finally, there is a summary of the research content.

*Department of Economic Management, Changzhi Vocational and Technical College, Changzhi, 046000, China (lingjie 202110@163.com)

2. Related Works. The construction of performance evaluation models can clarify the development direction of enterprises and promote their rapid development. A Diab et al. established a performance evaluation system for elastomers in various environments in order to study their properties in high and medium temperature environments, and the results showed that the evaluation system accurately assessed the performance indexes of elastomers at high temperatures and provided guidance for material improvement of elastomers, the evaluation system proposed by A Diab et al. is only applicable to the evaluation of material items, but it can still clarify the future improvement direction of materials [3].

LM Ciancetta et al. designed a performance feedback evaluation system to explore the performance of the rebound effect, and this showed that the system showed that people of different genders have different sensitivities to rebound-related terms, and pointed out that women are less sensitive, the performance evaluation system proposed by LM Ciancetta only considers a single indicator and does not fully consider the evaluation objectives [4].

AI Kusumah et al. designed a structural equation model led by women to investigate the mediating and reconciling role of employee performance appraisal, and hotel employees. The transformational leadership has a prominent active influence in employee performance and provides a clear direction for the company's leadership development program, the employee performance evaluation system proposed by AI Kusumah only focuses on the performance evaluation of leadership level employees, and pays less attention to the performance evaluation of basic employees [5].

To study the performance appraisal effect on employee career development, L Rahayu et al. surveyed a sample of employees in a logistics company through questionnaires and least squares data analysis, verifying that performance appraisal also exists active impact on worker's career development has a positive and significant impact, and based on this result, this logistics company improved the performance appraisal, conducted vocational skills training for employees, and increased the staff's identification with the company, the performance evaluation proposed by L Rahayu only focuses on employee skill training and does not pay attention to the development status of the enterprise [6].

MP Soni et al. In order to study the impact of gender differences in performance appraisal, they used a closed-ended questionnaire and controlled for factors such as the educational background of the respondents, and the results showed that the impact of gender differences on performance appraisal , mainly focused on the perceived basis of employees' work-oriented behavioral attitudes, the method proposed by MP Soni has a very clear subjectivity in data sources and lacks objective facts, therefore, the evaluation effect of the system is poor [7].

MT Kuo et al, in order to find the best scheduling strategy for energy storage devices when self-healing after fault detection in microgrid, proposed the Artificial bee colony (ABC) and applied it to the operation scheduling strategy of energy storage devices, and the results showed that the control of energy storage devices by ABC can meet the resource demand of microgrid and reduce the peak load in critical period, However, the parameter settings in this method are relatively vague and can still be adjusted [8].

W Alomoush et al, in order to solve the problems of fuzzy C-mean algorithm in image segmentation, which cannot relate to the context, high noise sensitivity and easy to fall into local optimum, proposed ABC algorithm built on fuzzy clustering, and the results showed that the comprehensive performance of this method is more excellent compared with other statistics, this algorithm only solves the problem of fuzzy clustering easily falling into local optima, and its performance is still poor when facing complex data [9].

X Wang et al, to address the matter that it is difficult to efficiently and accurately perform single inversion for stratigraphic parameters Wang et al. proposed an inversion method combining ABC and damped least squares algorithm to solve the problem of inversion and reconstruction of stratigraphic parameters in a single inversion, and the results showed that the method has not only the advantage of ABC, but also the high accuracy and fast convergence of damped least squares algorithm, this method is prone to getting stuck in local optima when using ABC to optimize the parameters of the least squares method [10].

R Yao et al. found that the hysteresis model is complex and non-differentiable, which leads to the complexity of gradient acquisition, and to solve this problem, the authors proposed an improved ABC and used it for the identification of lag parameters, and finally verified the feasibility of the method in the identification of nonlinear hysteresis parameters, although this method improves the identification performance of nonlinear

Table 2.1: Detailed information of the literature survey

Author	Method	Defect
Diab	Elastomer performance evaluation systemElastomer performance evaluation system	Not universal
LM Ciancetta	Emotional rebound evaluation system	No men were considered
AI Kusumah	Employee performance evaluation system	For employees only
L Rahayu	Questionnaire survey	Do not pay attention to the enterprise development
MP Soni	Questionnaire survey	Too many subjective factors
MT Kuo	ABC	The parameter setting is not reasonable
W Alomoush	A fuzzy clustering approach based on the ABC	Easy to fall into the local optima
X Wang	Combining ABC and damping least-squares methods	Easy to fall into the local optima
R Yao	Improve ABC	The parameter setting is not reasonable
Tuncer	ABC	The improvement effect is not obvious
Xu W	LSTM	The defects were summarized but not resolved
Xu Y	LSTM	It is easy to show the overfitting phenomenon
Punia S	Combining LSTM with random forest algorithms	It is easy to show the overfitting phenomenon
Chen C	And the LSTM based on deep learning	The training sample demand is too high

hysteresis parameters, it does not consider the identification problem of other linear parameters [11].

A Tuncer found that the traditional algorithm, can only provide small-scale solutions for the N-puzzle problem, to achieve the solution of the 15-puzzle problem, the authors proposed a new algorithm built on the metaheuristic algorithm, which divides the puzzle, and uses ABC to solve the divided the results show that the method helps significantly in solving the 15-puzzle problem, this method only divides the problem, simplifies the solving steps, but has little effect on the solving calculation of the problem [12].

Long and short memory network is widely used in the field of data prediction, XuW et al. In order to evaluate the prediction effect of LSTM for river flow, the results show that the full connection layer will reduce the learning efficiency of LSTM, leading to poor training effect, the author effectively evaluated the influence of LSTM parameter setting on its performance, but did not propose how to optimize [13].

In order to assess post-earthquake disasters, XuY et al proposed a framework based on LSTM. The results show that the framework is effective in assessing disasters, but this method causes overfitting phenomenon due to parameter setting problems [14].

A regression prediction method combining LSTM with the random forest algorithm was constructed and examined in true multivariate datasets. The results show that the statistical effect of this method is better, but the demand for parameters of this method is high, and the fitting phenomenon has appeared [15].

Chen C In order to improve the accuracy of rainfall prediction, et al. proposed a LSTM network based on deep learning. The results showed that LSTM predicted better, but the training sample of this method team is large, and the data acquisition is difficult [16].

To sum up, through the careful investigation of relevant literature, it can be found that most of the existing performance evaluation system for employees, regardless of the enterprise comprehensive financial performance, the traditional ABC algorithm in the training process has been fitting or into local optimal situation, and LSTM in data prediction, there are parameter optimization and data acquisition difficulties. Therefore, an enterprise financial performance evaluation system was studied, constructed, and the ABC algorithm was improved to optimize the optimization process. Then the optimized ABC algorithm was used to optimize the LSTM parameters and realize the adjustment of LSTM parameters. Finally, LSTM is used to evaluate the financial performance of enterprises, so as to realize the future development direction planning. Details of the references of the study investigated in related work are shown in Table 2.1.

3. Construction of financial evaluation model based on swarm algorithm.

3.1. Index system construction of LSTM-based financial performance evaluation model. The performance evaluation system has a certain guiding effect on the self-reflection of enterprises. In the business world, the main body is small and medium-sized enterprises, and large enterprises and small and micro enterprises are only a few, so the financial performance evaluation model designed by the research is designed

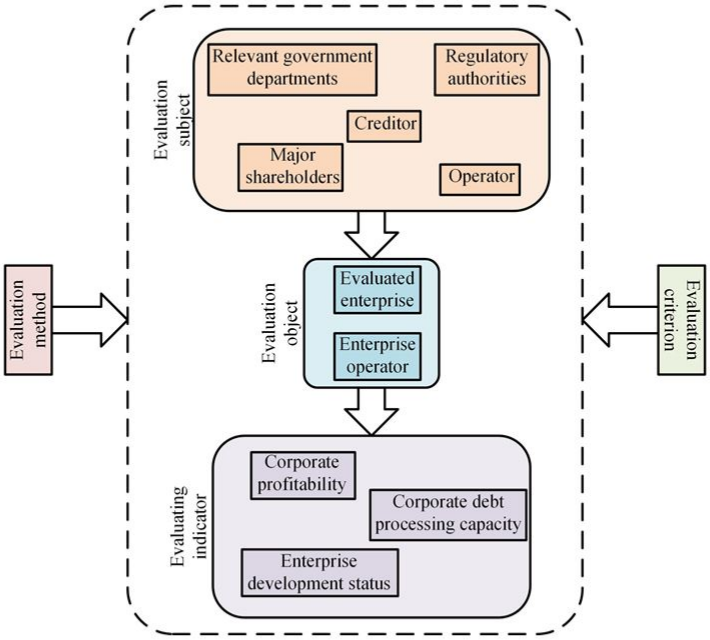

Fig. 3.1: General structure diagram of the evaluation model

for small and medium-sized enterprises (SMEs), and the financial performance evaluation model is usually composed of the following five basic elements. The first is the evaluation subject, the evaluation subject is generally the enterprise's stakeholders, the evaluation subject of SMEs is more complex, including enterprise shareholders, operators and relevant government departments, etc. The evaluation indexes of each rating subject are different, such as shareholders are generally based on the profitability of the enterprise and the rest of the indexes are supplementary, operators are based on the development content of the enterprise's operation status and enterprise development vitality, and relevant government departments are based on the social value of the enterprise. The second is the evaluation object, the evaluation object is the evaluated enterprise, and the operator of the enterprise, the evaluation object indicators, determined by the content of the evaluation subject, the third is the evaluation indicators, evaluation indicators are used to reflect the performance of the evaluation object in various aspects, the fourth is the evaluation criteria, evaluation indicators are based on the evaluation criteria, the performance of the evaluation object is evaluated, if Without evaluation criteria, the evaluation model is meaningless, and the fifth is the evaluation method, a suitable evaluation method can correctly and objectively reflect the performance of the evaluation object in all aspects. Fig. 3.1 lists the general structure of the evaluation model [1, 7].

SMEs are different from large enterprises, which usually have the following four development characteristics. Firstly, the scale of operation is small, SMEs are still in the adolescent stage in the life cycle of an enterprise, only having passed the infant and child stage with the help of capital, and have a larger scale compared to small and micro enterprises, but from the social level, the scale of operation of SMEs is still far from adequate. Secondly, the growth potential of SMEs is large, although the scale of SMEs is still small, but because they have broken through the early growth constraints, they can obtain a large amount of capital support with the help of listed financing and other means, so that they can develop rapidly, thirdly, the quality of enterprises is high and the level of debt is low, small and medium-sized enterprises are not at the early stage of development, the volume of investment and financing from various parties is low, and their own financial leverage Finally, the ability of sustainable operation is good, and SMEs can show good stability in the face of financial crisis and other problems, so that they will not collapse under the wave of financial crisis. The performance evaluation system of large enterprises has been relatively mature, as listed in Table 3.1 [18].

Table 3.1: Financial Performance Evaluation System for Central Enterprises

Asset status	Weight (%)	performance			
		Primary indicators	Weight (%)	Secondary indicators	Weight (%)
Profitability	34	Net asset income	19	Sales profit margin	11
				SSCM	8
		Total asset return	15	Cost-profit ratio	7
				RAROC	8
Asset	22	Asset turnover	16	Fixed asset ratio	9
				Current asset turnover	7
		Account turnover rate	6	cash recovery rate	6
Debt situation	22	Debt	13	quick ratio	7
				Current cash to liability ratio	6
		interest earned	9	Interest bearing debt ratio	5
				Debt ratio	4
Development status	22	Profit growth rate	10	Profit growth rate	10
		Total asset appreciation rate	12	Total Assets Growth Rate	6
				Technology investment ratio	6

The performance evaluation system constructed by the study focuses on SMEs, and the selection of financial performance evaluation indicators for SMEs should be based on the following four principles: first, systematicity, second, operability, third, comparability, and fourth, measurability. Inspired by Table 2.1, the study takes enterprise profitability, asset status, solvency and development capability as the primary indicators of enterprise financial performance evaluation, and sets up a total of 18 secondary indicators under the primary indicators. Under the indicator of profitability, there are five secondary indicators, namely Return on equity (ROE), Return on Total Assets (ROTA), Operating margin (OM), Ratio of Profits (RPC), and financial leverage coefficient (FLC), which are calculated in Equation (3.1).

$$\begin{cases} ROE = \frac{N}{A} \times 100\% \\ ROTA = \frac{P}{ATA} \times 100\% \\ OM = \frac{OP}{OR} \times 100\% \\ RPC = \frac{TP}{TC} \times 100\% \\ FLC = \frac{TP+IE}{TP} \times 100\% \end{cases} \tag{3.1}$$

In Equation (3.1),N represents net income for the reporting period,A represents average net assets,P represents net income,ATA represents average total assets,OP represents operating profit,OR represents operating income,TP represents total profit,TC represents total costs and expenses, andIE represents interest expense. Four secondary indicators are set under the asset position, namely Inventory turnover rate (ITR), Working capital turnover (WCT), Accounts receivable turnover rate (ARTR), and Current assets turnover rate (CTR). and current asset turnover (CAT), which are calculated in Equation (3.2).

$$\begin{cases} ITR = \frac{OC}{AIB} \\ WCT = \frac{LAO}{ABWC} \\ OM = \frac{NOI}{AAR} \\ CAT = \frac{NOI}{ACA} \end{cases} \tag{3.2}$$

In Equation (3.2),OC is operating cost,AIB is average inventory balance,IAO is operating income,$ABWC$ is average working capital balance,NOI is net operating income,AAR is average accounts receivable, andACA is average total current assets. Under solvency, five secondary indicators are set, namely Asset liability ratio (ALR), Interest bearing debt average interest rate (IBAIR), Quick ratio (QR), Dynamic debt repayment period (DDR), and Debt service ratio (DCR). Dynamic debt repayment period (DDRP), and cash ratio (CR), which

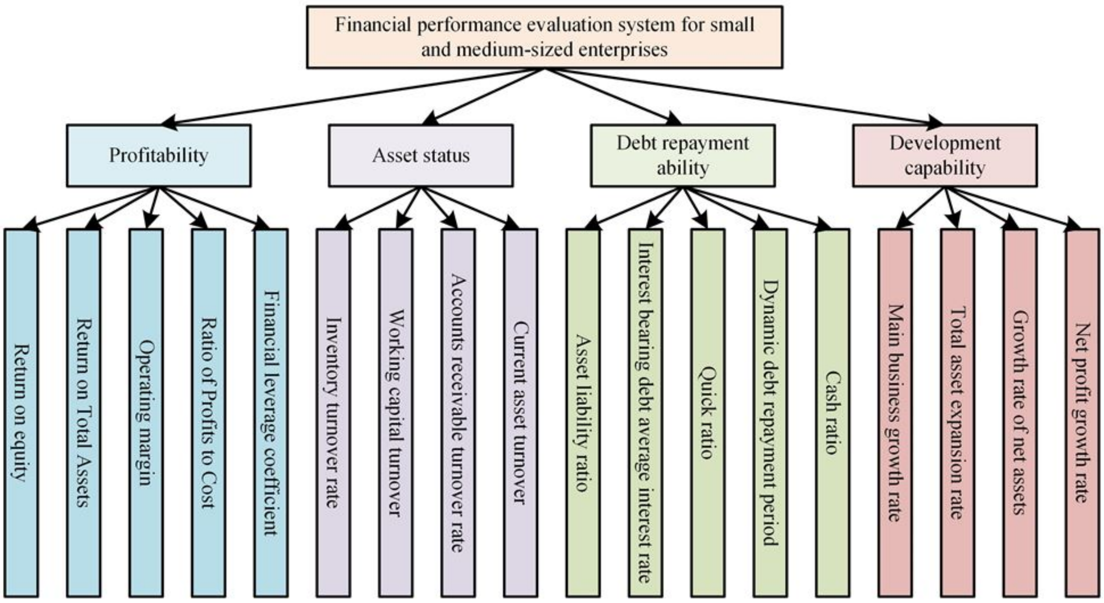

Fig. 3.2: Financial performance evaluation system for SMEs

are calculated in Equation (3.3).

$$\begin{cases} ALR = \frac{TL}{AIB} \\ IBAIR = \frac{LAO}{ABWC} \\ QR = \frac{NOI}{AAR} \\ DDRP = \frac{TL}{AOCF} \\ CR = \frac{MF+CE}{CL} \times 100\% \end{cases} \tag{3.3}$$

In Equation (3.3),TL is total liabilities,TA is total assets,IBD is interest-bearing debt,LA is quick assets,CL is current liabilities,$AOCF$ is annual operating cash flow,MF is money capital, andCE is cash equivalents. Four secondary indicators are set under development capability, namely Main business growth rate (MBGR), Total asset expansion rate (TAER), Growth rate of net assets (GRONA), Net profit growth rate (GRONA) and Net profit growth rate (GRONA), Net profit growth rate (NPGR), which are calculated in Equation (3.4).

$$\begin{cases} MBGR = \frac{C-PM}{PM} \times 100\% \\ TAER = \frac{T-TAO}{TAO} \times 100\% \\ GRONA = \frac{CNA-ONA}{ONA} \times 100\% \\ NPGR = \frac{NPG}{LY} \times 100\% \end{cases} \tag{3.4}$$

In Equation (3.4), C and PM are the main business revenue of the current and previous period. T is the total assets of the current year,TAO is the total assets of the previous year,CNA is the net assets at the end of the period,ONA is the net assets at the beginning of the period,NPG is the net profit growth of the current year, andLY is the net profit of the previous year. The financial performance evaluation system constructed by the study is shown in Figure 3.2.

Long Short-Term Memory (LSTM), an algorithm commonly used in performance evaluation, is studied as a basic method for financial performance evaluation, but the selection of its parameters is extremely important. In the LSTM algorithm, parameters such as the number of training times and the amount of hidden units will straightway affect the operation of the neural network, and the selection of parameters by experience alone will increase the training difficulty of the model and reduce the accuracy of the model, so the study uses ABC to optimize the parameter selection of LSTM [1, 9].

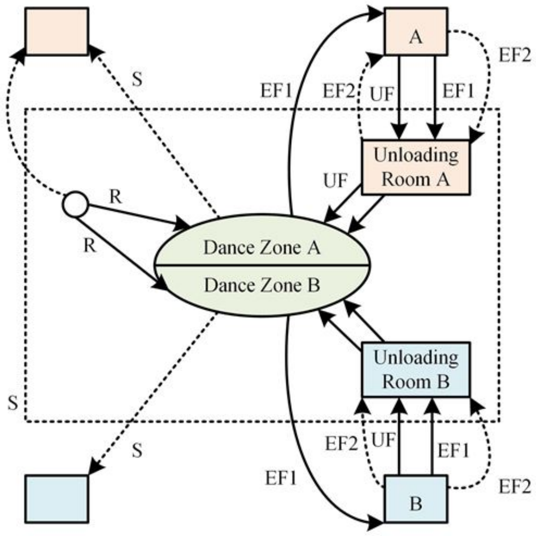

Fig. 3.3: Behavior diagram of Bees Collecting Honey

3.2. Financial evaluation model based on improved ABC. Honey bees are a swarming insect with a strict hierarchy and clear division of labor within its population. When bees go out to look for nectar sources, they have a fixed behavior pattern. Inspired by the behavior pattern of worker bees looking for nectar sources to collect honey, scholars have proposed the ABC algorithm, and the honey bee's honey collection process is shown in Figure 3.3 [20].

ABC algorithm is an intelligent optimization algorithm commonly used in image segmentation, data mining and other fields, which seeks the greatest solution by simulating the honey harvesting behavior of bees, in ABC, a honey source is the greatest plan of an issue, at the beginning of the algorithm, the honey source numbers need to be initialized, generally the number of honey sources is the same as the leading bees, assuming that the number of leading bees is B_N, the max iterations of honey sources is *Limit*, and the algorithm The max number of iterations of the algorithm is $Maxcycle$, then the bees search for the optimal honey, that is, to find the optimal solution of the objective function, as shown in Equation (3.5).

$$\min f\left(x_i\right),\left(i=1,2,\ldots,B_N\right) \tag{3.5}$$

The initial nectar source of the colony is randomly distributed, and the random function is given in Equation (3.6).

$$x_{i,j}=x_j^{\max}+rand\left(0,1\right)\left(x_j^{\max}-x_j^{\min}\right) \tag{3.6}$$

In Equation (3.6),i denotes the first$i$ honey source,j denotes the$j$ dimensional component of the solution space,$x_j^{\max}$, $x_j^{\min}$ is the upper and lower limits of the solution space ,$rand\left(0,1\right)$ denotes the random No. generated in [0, 1], and the basic flow of the ABC algorithm is shown in Figure 3.4 [21].

In the ABC algorithm, there are three kinds of bees in a colony, which are lead bees, follow bees and scout bees. After the initialization of the honey source, the lead bee determines the fuzzy location of the honey source and calculates the quality of that in the area, while the follow bee follows the lead bee and is responsible for recording the location of the optimal honey source. If a scout bee appears at this time, it will search for a new honey source location again and detect whether the maximum number of iterations is reached, or whether it meets In the ABC algorithm, each leader bee only collects its own corresponding nectar source, and if a better nectar source is collected during the collection process, the current leader bee updates the position of its own

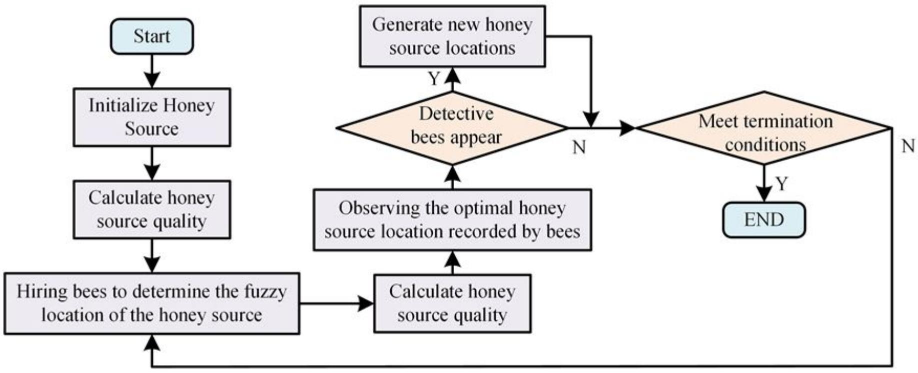

Fig. 3.4: ABC Algorithm Basic Flowchart

nectar source. In the ABC, each leader bee only collects its own corresponding nectar source, and if a better nectar source is collected during the collection process, the current leader bee updates its own nectar source location.

$$v_{i,j} = x_{i,j} + rand\left(-1, 1\right)\left(x_{i,j} - x_{k,j}\right) \tag{3.7}$$

In Equation (3.7),$v_{i,j}$ denotes the location of the new nectar source,i, k denotes the first$i$ or$k$ nectar source, and$rand\left(-1, 1\right)$ denotes the random No. generated in [-1, 1]. After searching for a new nectar source, the leader bee needs to judge the new nectar source according to the fitness function, which is shown in Equation (3.8).

$$fitness\left(i\right) = \begin{cases} 1/\left(1 + f_i\right), f_i \geq 0 \\ 1/abs\left(f_i\right), f_i < 0 \end{cases} \tag{3.8}$$

In Eq. (3.8),$fitness\left(i\right)$ denotes the fitness function value of the$i$ honey source, andf_i denotes the objective function value of the$i$ solution. The objective function value is inversely proportional to the fitness function value, and the larger the value of the fitness function, the higher the quality of the honey source, and in each iteration, the honey source with the larger fitness function value is always retained to get the best value of the objective function. The following bee will choose a leader bee to follow and conduct a local search around the leader bee to find a better nectar source. It has been confirmed by scholars that the larger the value of the fitness function of the leader bee, the higher the probability that the follower bee will choose the leader bee.

$$P_i = \frac{fitness\left(x_i\right)}{\sum_{i=1}^{B_N} fitness\left(x_i\right)} \tag{3.9}$$

In Equation (3.9),P_i indicates the probability that the i nectar source is selected by the following bee. The fitness value of the first$i$ honey source, the percentage of the sum of the fitness values of all honey sources, that is, the probability that the leader bee at that honey source location is selected by the following bee. Therefore, after reaching the first honey source location, the following bee will generate a random value within [0, 1], if the value is smaller, it will be updated once; If it is larger than the fitness value of the honey source, it will go to the next honey source, and so on, if the If all the nectar sources are not updated, the process starts again at the first nectar source until the nectar source is updated. If the number of unrenewals reaches$Limit$, then the honey source is discarded and a new honey source is generated according to Equation (3.6) at [22]. To optimize the local search capability of ABC algorithm and the honey source location update algorithm, the central solution idea and the differential evolution algorithm are proposed in the study and applied to ABC. The central solution idea is derived from Pontryagin's maximum principle or similar variational principles, which are based on optimal control theory and provide a systematic mathematical framework to analyze the behavior of control systems and find the optimal control strategy. To find a central solution, it is usually necessary to solve a series of nonlinear equations or inequalities, and also consider the constraints of the system, including constraints on control variables and state variables. By solving these problems, a determined optimal path can be obtained, which not only satisfies the dynamic equations and boundary conditions, but also meets the requirements of minimizing the given performance indicators. After adding the central solution idea, a central solution will be generated at the end of each swarm iteration, and the calculation of the central solution is shown in Equation (3.10).

$$x_{0,j} = \frac{1}{B_N}\sum_{i=1}^{B_N} x_{i,j}, 1 \le j \le D \tag{3.10}$$

In Equation (3.10),$x_{0,j}$ denotes the central solution on the$j$ th dimensional vector. DE is an evolutionary algorithm suitable for multi-objective optimization problems. DE is particularly suitable for handling continuous, high-dimensional, nonlinear, uncertain, constrained, and multimodal optimization problems, and is widely used in optimization problems in engineering design, control systems, data mining, and other scientific fields. DE is easy to implement, with fewer parameters and intuitive adjustments, making it an efficient global optimization algorithm. The algorithm continuously adapts to different problems during the iteration process, adjusting the search strategy to find the global optimal solution or acceptable solution. DE can handle various types of optimization problems, especially in nonlinear and non convex problems, demonstrating good robustness. Due to the fact that the population of DE can be dispersed for computation, this algorithm has natural parallelism and is suitable for modern multi-core processors to accelerate computation. The improvement of the differential evolutionary algorithm to the honey source location calculation is mainly to use the variational operator as the new update formula and the current optimal solution as the location update guide in the variational engineering, but in this process, due to the excessive emphasis on local search, resulting in easily falling into the local optimum, in order to solve the problem, the research not only combines the central idea in the basic algorithm, but also combines the dynamic adjustment factor, combined with the dynamic adjustment factor. After combining the dynamic adjustment factor, it can make the basic algorithm and can automatically adjust the search range, which combined with the dynamic adjustment factor is demonstrated as Eq.(3.11).

$$v_{i,j} = x_{0,j} + \varphi\omega\left(x_{i,j} - x_{0,j}\right) \tag{3.11}$$

In equation (3.11),ω is the dynamic adjustment factor, which is calculated in equation (3.12).

$$\omega = \omega_{\max} + \frac{\left(\omega_{\max} - \omega_{\min}\right)\left(iter_{\max} - iter\right)}{iter_{\max}} \tag{3.12}$$

In Equation (3.12), $iter_{\max}$ is the max iterations,$iter$ denotes the current iterations, and$\omega_{\max}, \omega_{\min}$ is a constant that indicates the honey source search range of the bee colony. The study applies the optimized ABC to the LSTM-based financial performance evaluation model, keeping the structure of the LSTM model unchanged, to find out the global optimum of the parameters and improve the accuracy of the performance evaluation model according to the objective function, which is displayed in Equation (3.13).

$$loss = \frac{\sum\left(y_i - y_{true}\right)}{n} \tag{3.13}$$

In equation (3.13),y_i is the model evaluation value,y_{true} is the true value,$loss$ the target loss value, and$n$ is the sample size. The smaller the loss value of the objective function, the more accurate the model is. The study chose the Adam algorithm in the learning algorithm of the LSTM algorithm, which is calculated as shown in Equation (3.14).

$$f\left(x\right) = \frac{1}{1 + \ell^{-2x}}\left(0 < f\left(x\right) < 1\right) \tag{3.14}$$

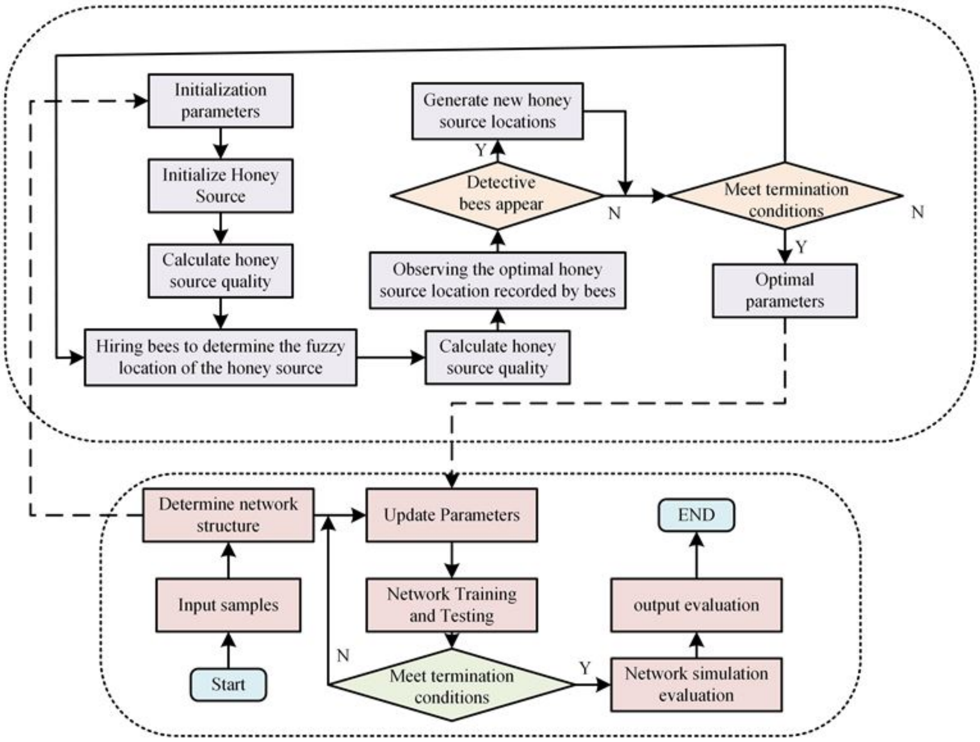

Fig. 3.5: LSTM algorithm flowchart for ABC algorithm optimization

In Equation (3.14),x denotes the parameters. The activation function of the algorithm is shown in Equation (3.15).

$$g\left(x\right)=\frac{1-\ell^{-2x}}{1+\ell^{-2x}}\left(-1<g\left(x\right)<1\right) \tag{3.15}$$

The flow of the LSTM algorithm optimized using the ABC algorithm is shown in Figure 3.5.

4. Simulation results analysis of the financial performance evaluation model grounded on ABC.

4.1. Performance analysis of LSTM algorithm optimized by improved ABC. To verify the effectiveness of the study on the improvement of the ABC, the study simulated the optimal solution of the Sphere and Rosenbrock function using the improved algorithm in the simulation environment of MATLAB 7.0, and the results are shown in Figure 4.1.

Figure 4.1(a) shows the simulation of solving the optimal solution of the two algorithms for the Ackley function. Fig. 4.1(b) is the simulation of solving the optimal solution of the two functions for the Griewank function. In Figure 6(a), the improved ABC completes the convergence of the optimal solution at the 800th iteration, and the ABC algorithm completes the convergence of the optimal solution at around the 1400th iteration. In Fig.6(b), the improved-ABC obtains the optimal solution at the 400th iteration and completes convergence at the 1000th iteration, and the ABC obtains the optimal value only at around the 1000th iteration and does not complete convergence at the 2000th iteration. The study was conducted after completing the comparison of improved ABC with ABC for the training situation of the LSTM model, and the results are displayed in Figure 4.2.

Figure 4.2(a) shows the variation of the mean square error in the model training, and Fig. 4.2(b) shows the variation of the loss degree in the model training. In Figure 4.2(a), the mean square error (MSE) of the

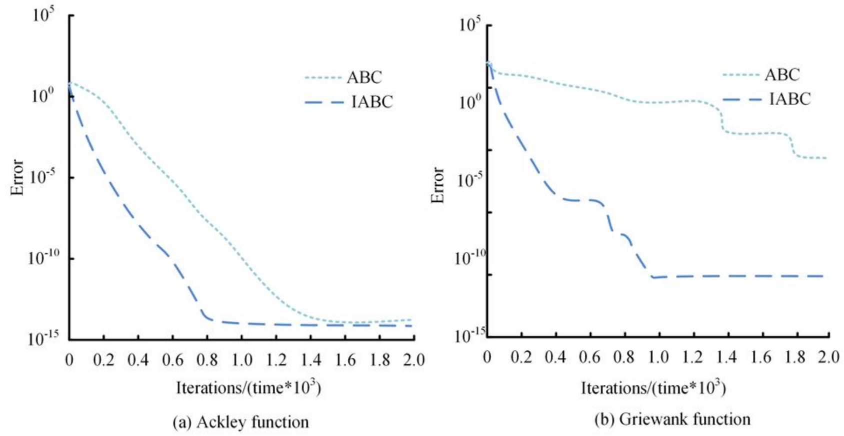

Fig. 4.1: Comparison of Improved ABC and ABC for Function Optimal Solution

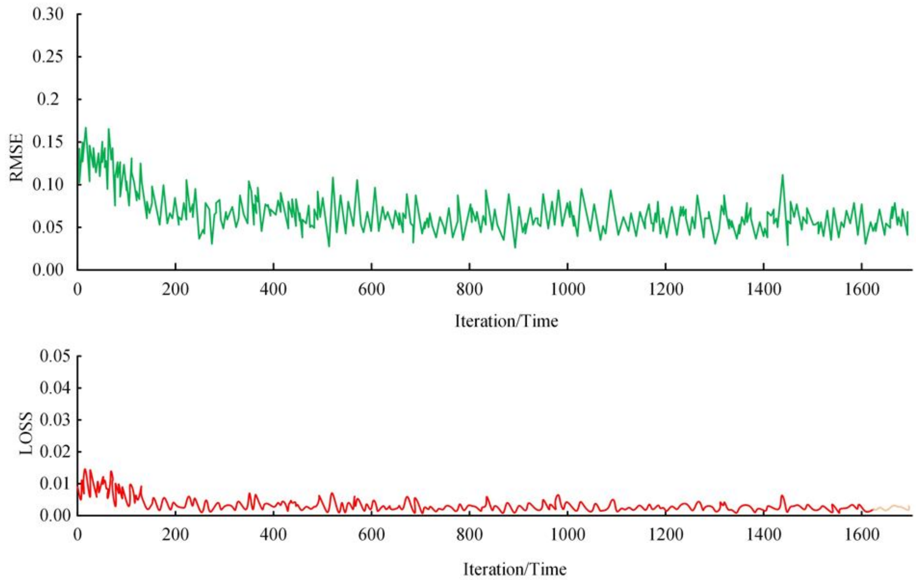

Fig. 4.2: Training Results of LSTM Network Mode

model gradually decreases with the increase of the iterations before 200, and the MSE of the model tends to be smooth after the number of iterations is higher than 200. In Fig. 4.2(b), the loss degree of the model gradually decreases to less than 0.01 before 200 iterations, and the loss degree of the model tends to be smooth and no longer decreases and tends to 0 above 200 iterations.The study finally compares the errors of the LSTM financial performance evaluation model based on the improved ABC optimization with those of the commonly used performance evaluation models such as the LSTM-based financial performance evaluation model. The results are shown in Figure 4.3.

In Figure 4.3, it can be seen that all the errors of the algorithms are lower than the other algorithms, and the ABC-LSTM algorithm has an MBE value of -0.121, MAE value of 0.0453, MSE value of 0.0683, and RMSE value of 0.0047, which is basically the same as the algorithm, and the cluster analysis algorithm has the lowest MSE value of 0.0908, and its error variation with the algorithm.

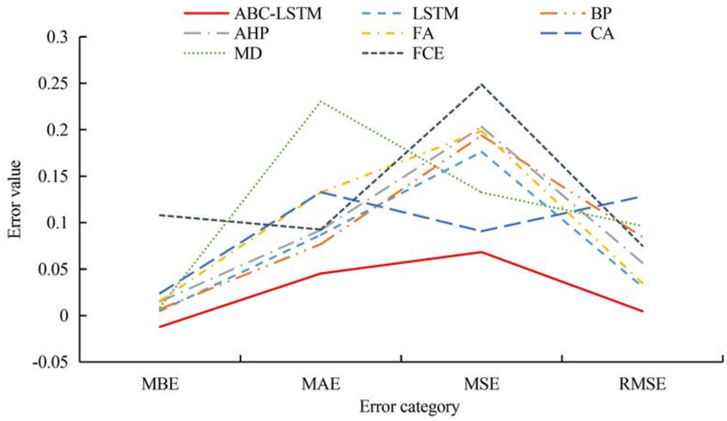

Fig. 4.3: Error Comparison of Performance Evaluation Models

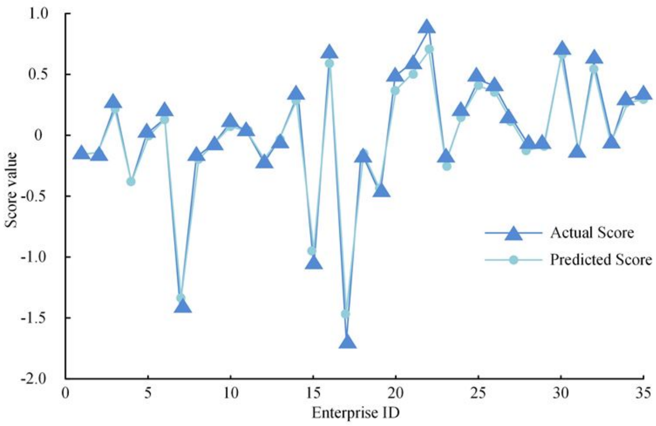

Fig. 4.4: Algorithm fitting result

4.2. Simulation results analysis of the performance evaluation model. After verifying the performance of the method proposed by the study, the study fitted the model's score for a firm to the actual score value of that firm, and the results are shown in Figure 4.4.

In Fig. 4.4, the predicted scores of the model proposed by the study fit well with the actual score values of the enterprise, where sample No. 17 has the worst fit with an error of about 0.25, samples No. 14, 15, 16, 20, 21 and 22 have the second best fit with an error less than or equal to 0.1, and the rest of the samples have an extremely good fit. The study concluded that the model has met the requirements of financial performance assessment, and then the study used the model to evaluate the financial performance of 25 samples randomly selected from SMEs in a country for the first-level indicators, and Table 4.1 shows the results.

As can be seen in Table 4.1, about half of the 25 enterprises have a composite score below 0. Among the four primary indicators of these enterprises with a score below 0, three of them have a negative score. In order to further observe the situation of these enterprises, the secondary indicators of some enterprises with negative scores were evaluated, and the specific scores are shown in Table 4.2.

In Table 4.2, it can be seen that the lowest score of TAER is -5.387 among the 18 items evaluated by company #2, and the lowest score of CAT is -8.920 for sample #7. Although sample #17 has the lowest overall score, its score for each item is not the lowest , and the lowest score of OM is -6.012 for sample #17. 8 of the

Table 4.1: Score of Enterprise Level 1 Indicators

Enterprise ID	Profitability	Asset status	Debt repayment ability	Development capability	Comprehensive score
1	0.156	-0.083	-0.674	-0.510	-0.149
2	-0.112	0.351	-0.337	-0.965	-0.150
3	0.270	0.138	0.475	0.167	0.220
4	-0.013	-0.928	-0.628	-0.268	-0.41
5	0.103	0.036	0.332	-0.602	0.002
6	0.334	0.356	-0.258	-0.262	0.132
7	-0.185	-5.301	-0.345	0.058	-1.340
8	0.221	-0.374	0.148	-0.127	-0.192
9	-0.175	0.331	-0.457	-0.002	-0.067
10	0.451	0.149	-0.667	-0.062	0.079
11	-0.224	0.767	-0.419	0.041	0.038
12	0.102	-0.074	-0.762	-0.702	-0.205
13	-0.074	0.441	-0.336	-0.378	-0.030
14	0.812	0.274	-0.437	0.021	0.320
15	-2.460	0.384	-0.198	-0.362	-0.951
16	1.128	0.512	0.476	-0.168	0.586
17	-4.018	0.653	-0.168	-0.531	-1.453
18	-0.234	0.338	-0.398	-0.501	-0.147
19	-0.852	.167	-0.352	-0.598	-0.439
20	-0.721	0.074	-0.218	5.384	0.378
21	0.637	0.682	-0.135	1.052	0.517
22	2.193	0.329	-0.827	-0.034	0.689
23	-0.035	-0.753	-0.118	-0.002	-0.244
24	0.006	-0.203	1.629	-0.345	0.163
25	0.673	0.384	0.405	0.061	0.411

Table 4.2: Score of Enterprise Secondary Indicators

/	2	7	9	12	15	17	18	1 9	23
ROE	0.231	-0.321	0.233	-2.311	3.231	-0.421	0.561	-0.321	-0.321
ROTA	-0.084	-0.361	-0.056	-3.321	-2.284	-0.381	2.684	-0.381	-0.121
OM	-0.358	3.012	-0.358	2.412	-1.358	-6.012	-3.368	2.015	-1.122
RPC	-0.121	-3.842	-0.141	-3.342	-3.121	1.442	-1.521	1.642	-3.432
FLC	0.084	-2.382	0.086	-2.372	3.084	2.382	-0.684	-3.882	-2.651
ITR	0.135	-0.351	0.835	-5.351	2.135	-1.331	3.135	-1.451	2.348
WCT	1.352	-2.384	1.362	-2.384	3.352	-3.374	-2.352	-2.286	3.014
ART	-0.130	-3.350	-0.150	-3.255	-2.130	-3.450	-0.130	-2.340	-3.450
CAT	0.653	-8.920	0.753	-2.920	1.653	3.720	0.453	-4.620	2.820
ALR	0.135	-0.341	0.125	-2.341	2.335	3.541	1.125	-0.131	1..341
IBDAI	-1.380	1.320	-1.980	1.892	-2.380	3.120	-3.150	-1.220	1.389
QR	-0.290	-0.384	-0.290	-0.484	-3.290	-2.414	1.691	-2.331	-1.364
DDRP	0.009	-2.384	0.039	-2.399	1.239	1.344	-1.139	1.384	-3.364
CR	1.235	0.312	1.835	0.319	2.235	1.132	-1.465	0.308	1.312
MBGR	0.061	-0.251	0.361	-0.161	4.361	-3.251	1.261	-0.281	0.451
TAER	-5.387	1.382	-5.379	1.366	-4.387	3.322	-2.782	-0.312	-2.382
GROA	-1.248	0.348	-1.292	0.368	-2.348	-3.148	-2.360	-1.257	-1.348
NGR	-0.310	0.320	-0.390	0.840	2.315	3.210	1.330	0.620	2.820

18 items scored by 17 have negative scores for the indicators. Among the items with positive scores in sample 17, the highest score was the CAT score, which was 3.720.

5. Conclusion. In order to verify the effectiveness of the ABC algorithm improvement, the optimal solution solving simulation of the Sphere function and Rosenbrock function was conducted in MATLAB 7.0. The experimental results show that the improved ABC algorithm obtains the optimal solution and completes convergence after 800 and 400 iterations, respectively, while the original ABC algorithm requires more iterations.

Subsequently, the training of the LSTM model showed that after 200 iterations, the mean square error and loss of the model reached a stationary state. The model compares the financial performance score of the enterprise with the actual score and finds that the predicted results of the model are consistent with the actual situation. The MBE value of the ABC-LSTM algorithm is -0.121, the MAE value is 0.0453, the MSE value is 0.0683, and the RMSE value is 0.0047. Among the algorithms, the clustering analysis algorithm has the lowest MSE value of 0.0908, indicating the best performance of the proposed algorithm. In the first level indicator evaluation of 25 samples of small and medium-sized enterprises, more than half of the enterprises have a comprehensive score below zero. The research has confirmed the effectiveness of the LSTM model optimized based on the improved ABC algorithm in enterprise financial performance evaluation. The proposed enterprise financial performance evaluation method can accurately evaluate the development of enterprise financial performance, help enterprises clarify their future development direction, and make their development more stable and rapid. Although the method proposed in the study can accurately evaluate the development status of a company's financial performance, the computational cost of this method is relatively high. Future research can further optimize algorithms to reduce computational costs and verify algorithm stability in changing environments, in order to be more widely applied to actual financial performance evaluation.

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