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An Improved Wavelet Neural Network Model for Evaluation of Corporate Performance

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Abstract: For improving the wavelet neural network model, the momentum rate was used for dynamic improving the network parameters learning rate and Error entropy function were used for accelerating the network convergence rate. The improved model was applied in a comprehensive energetic evaluation of some listed companies to find out the China's building enterprises' performance in recent years. The results show that the wavelet neural network as an expert evaluation system could make the evaluation rapidly and efficiently. The wavelet neural network has a unique capacity when a comprehensive dynamic evaluation of the weight accurately calculates is difficult. The results also show that the most corporate performances were low and fluctuation in every year, so the management needed to be improved.

Key words: Corporate performance, improved wavelet neural network model, comprehensive dynamic evaluation, China's building enterprises

INTRODUCTION

Corporations are the subject of the micro-economic activity and their operating conditions have a direct bearing on the development of the entire economy, the enterprise survival and social stability. Enterprise performance evaluation systems are great significance to improve the scientific enterprise management level and to promote the enterprise sustainable development.

The research of corporate performance evaluation began relatively late in China. The main evaluation methods are such as the Principal Component Analysis (Yang *et al*., 2008), the Factor Analysis, Data Envelopment Analysis (DEA) (Wang, 2008) and Economic Value Added (EVA) . The Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) (Lin and Zheng, 2008), the Gray Correlation Analysis, BP Artificial Neural Network and Multi Strategy Evaluation Method are as the subordinate method. Although there has been a number of useful study results, however, the present research is not very enough. Firstly, scholars are not consensus in the calculation of weight, many researches are main to explore calculation methods of the weight. Secondly, the present researches primarily on static evaluation-oriented, that is, to one year of the data to study (Yang *et al*., 2008; Wang, 2008; Lin and Zheng, 2008) and the sample's time affects the results. Although there is the average correction sample in some research to overcome the effects and the results are more objective, but do not reflect corporate performance changes over time, so it still has some shortcomings.

Recently, the WNN have become a popular tool in networks. The wavelet neural network has the unique premium properties, such as parallel implementation, self-organizing, self-adaptation, self-learning capability and fault tolerance and it is much more suited to learn than other types of neural networks (Khan and Rahman, 2010). WNN has been used to forecasting (Li *et al*., 2013), evaluate, signal processing, data compression, pattern recognition, fault diagnosis, control and more many scientific and engineering areas (Ma *et al*., 2012; Gao *et al*., 2012; Lin *et al*., 2010). The wavelet neural network is in a better position to deal with the problems, such as mass factors, uncertainties and nonlinear in performance evaluation (Tang and Xu, 2007). The method overcomes the problem that the traditional evaluation model is dependent on the specific parameters.

The article aims at getting the weight index by the wavelet neural network. The first, enterprise performance was divided into six ranks and the evaluation system was constructed through the randomly generate data of indicators at all levels and different levels of expectancy distinguish the performance results. The nonlinear mapping of integrated assessment that from the indicator natures to the outputs was established through the wavelet neural network learning. Then, the indicators' data of the construction companies were put into the wavelet neural network model which has been trained and the corporate performances were gotten.

The rest of the paper is organized as follows. In Section 2, Wavelet Neural Network (WNN) is described. In Section 3, China's Listed Building Enterprises' Performance are studied. Finally, a conclusion is provided in Section 4.

METHOD DESCRIPTION

Wavelet neural network (WNN) was proposed by Zhang and Benveniste (1992) of IRISA. WNN is a new feed-forward network based on wavelet analysis which a non-linear wavelet function was employed replaced the BP network Sigmoid function. WNN introduces the wavelet decomposition property into a general neural network and combines the advantage of time-frequency location of the wavelet transform and self-learning capability of artificial neural networks (Yang *et al*., 2008) and has very excellent nonlinear mapping function. WNN not only overcomes the shortcomings of the pure neural network easily get into the local maximum, slow convergence, but also optimized the neural network structure, increased network speed and improved accuracy. The Multilayer Perception (MLP) with the back-propagation (BP) training algorithm is the mostly used type of neural network in practical application. But this structure is complicated due to multilayer structure and its convergence is too slow. The RBF network has a simpler structure (one hidden layer) than the MLP. The training of the RBF networks can be obtained much easier than the MLP networks by preprocessing the training data, such as clustering.

Model overview: WNN has the feature of Uniform approximation and L_2 approximation. WNN structure is as shown in Fig. 1.

Where N is the numbers of samples, the numbers of input layer nodes are m, the numbers of hidden layer nodes are n, the numbers of output layer nodes are 1. x^i_k is the ith indicator of the kth sample, r^i_k is the normalized value of ith indicator of the kth sample. y_k is the output corresponds to kth sample. v_j is the weight coefficients connected hidden layer nodes j with output layer nodes; w_{ij} is the weight coefficients connected input layer nodes i with hidden layer nodes j; ψ_i (a_j, b_j) is the Wavelet Activate function from hidden hidden layer to output layer, a_j and the b_j is dilation parameters and translation parameters of jth hidden layer nodes; d_k is the expectant output of kth sample; Linear function was used in output layer and WNN model is as follows:

$$y_k = f\left(\sum_{j=1}^{n} v_j \psi_{a,b}\left(\sum_{i=1}^{m} w_{ij} r^i_k\right)\right) \quad (1)$$

The precondition for wavelet analysis is selected the appropriate basic wavelet function. Three different wavelet families were used, such as the Morlet, the Gaussian wavelet and the Mexican Hat. The selection of the wavelet function $\psi(x)$ should meet the framework restriction as follows:

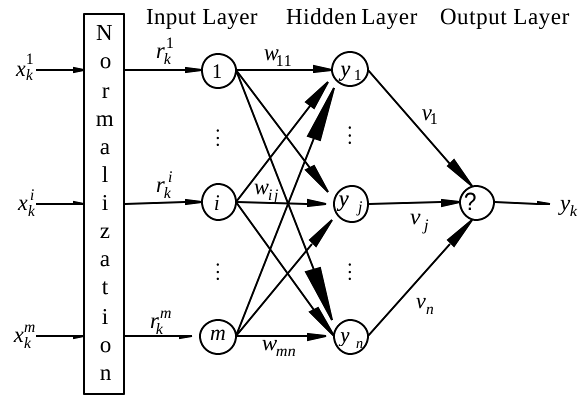

Fig. 1: Wavelet neural network structure

$$A\|f\|^2 \le \sum_j \sum_i \langle \psi_{ji}, f \rangle^2 \le B\|f\|^2$$

A and B is the upper and lower of the framework restriction. Distinctive wavelet function was used in different. In the evaluation, the scholars generally select the Morlet wavelet function which is a Cosine-modulated Gaussian beam, with almost no spare space in the framework B/A≈1:

$$\psi(t) = \cos(1.75t)\exp(-t^2/2)$$

Improved model and modeling steps: In order to accelerate the network convergence rate, the dynamic improving learning rate and Error entropy function were used for training the network parameters.

The x^i_k is the input sample, the y_k is the actual output, the d_k is expected output. The process of improved model is as follows:

Normalize The input data: There are definite differences between the distinctive indicators in a range. To avoid the training get to the extreme in the flat region of the network, the samples were normalized at first. The efficiency indicators were normalized by the Eq. 2a and the cost indicators were normalized by the Eq. 2b. The r_{ik} is the normalization sample series:

$$r^i_k = \frac{0.9-0.1}{x_{max}-x_{min}} x^i_k + (0.9 - \frac{0.9-0.1}{x_{max}-x_{min}} x_{max}) \quad (2a)$$

$$r^i_k = \frac{0.9-0.1}{x_{max}-x_{min}} x_{min} + (0.9 - \frac{0.9-0.1}{x_{max}-x_{min}} x^i_k) \quad (2b)$$

Define the network structure: The amount of input layer nodes m and the amount of output layer nodes 1 is defined by the model characteristics of the sample. The numbers of hidden layer nodes n are defined by min (m, 1)<n≤2m+1. The weights and the initial Dilation Coefficient and Translation Coefficient all are decimal of uniform random distribution and the range is $(-3/\sqrt{p}, 3/\sqrt{p})$, p = m×n, n, n, n.

Train sample data according to Eq. 1. To be consistent with the actual in the error entropy function calculation, the sample data input is at random:

$$E = -\sum_{k=1}^{N}\left[d_k \ln y_k + (1-d_k)\ln(1-y_k)\right] \tag{3}$$

Dynamically changes the network parameters learning rate η. If the mean square error E(t) reduced after the weight updated, then the weight, wavelet coefficients and other network parameters update are accepted, learning rate will be multiplied by a factor α>1, that is η(t) = αη(t-1). If the error increase after adjusted, the adjustment of parameters is rejected, then this network parameters updated should be canceled, learning rate will be multiplied by a factor β<1, that is η(t) = βη(t-1).

Through the network parameters changing repeatedly, the WNN model could get the calculation accuracy rapidly because of the ability of memory and generalization and the accelerating convergence. The hypothesis is:

$$net_k^j = \sum_{i=1}^{m} w_{ij} r_k^i,\quad \psi_{a,b}\left(net_k^j\right) = \psi\left(\frac{net_k^j - b_j}{a_j}\right)$$

and mc is the momentum rate. The grades of the weights of output layer δ_{vj}, the weights of the hidden layer δw_{ij}, a_j and b_j is changed through calculating the mean square error:

$$MSE = \frac{1}{2}\sum_{k=1}^{N}(y_k - d_k)^2$$

according to Eq. 4 to Eq. 7.

$$\delta_{v_j} = -\sum_{k=1}^{N}(d_k - y_k)\psi_{a,b}\left(net_k^j\right) \tag{4}$$

$$\delta_{w_{ij}} = -\sum_{k=1}^{N}(d_k - y_k)v_j\psi'_{a,b}\left(net_k^j\right)r_k^i / a_j \tag{5}$$

$$\delta_{a_j} = -\sum_{k=1}^{N}(d_k - y_k)v_j\psi'_{a,b}\left(net_k^j\right)\left(\frac{net_k^j - b_j}{a_j}\right)/a_j \tag{6}$$

$$\delta_{b_j} = -\sum_{k=1}^{N}(d_k - y_k)v_j\psi'_{a,b}\left(net_k^j\right)/a_j \tag{7}$$

Then, changes v_j, w_{ij}, a_j and b_j. The changed parameters are as follows:

$$\begin{aligned} v_j(t) &= v_j(t-1) - \eta\delta_{v_j} + mc\Delta v_j(t-1) \\ w_{ij}(t) &= w_{ij}(t-1) - \eta\delta_{w_{ij}} + mc\Delta w_{ij}(t-1) \\ b_j(t) &= b_j(t-1) - \eta\delta_{b_j} + mc\Delta b_j(t-1) \\ a_j(t) &= a_j(t-1) - \eta\delta_{a_j} + mc\Delta a_j(t-1) \end{aligned} \tag{8}$$

This process should be repeated and the parameters should be changed in the process. The training parameters should be output when the condition is fitted to the end.

The object to be evaluated is normalized according to the Eq. 2. And the normalized series r'^i_k are input to the trained network and get the evaluation results.

EMPIRICAL RESEARCH OF CHINA'S LISTED BUILDING ENTERPRISES' PERFORMANCE

Construction is the infra-structural industry and pillar industry in the Chinese economy. The construction has made important contributions to the sustainable health development economy and social stability.

Evaluation object and the source of data: Considering the listed construction company's management is regular, the Chinese listed construction companies are as the research samples. By the beginning of 2009, there are 36 listed construction companies in stock markets of Shanghai and Shenzhen in total, since Shenzhen Universe (Group) Co., Ltd became listed on Shenzhen stock markets in 1993.

The new Enterprise Accounting System was implemented by the listed companies in 2001. The vast majority listed company's accounting policies have to be adjusted according to the new system and resulting in overall performance levels fallen in 2001. So, the objects of study were that became a listed company before 2002 or in 2002 and the time of study was from 2002 to 2007. The income from building construction was more than 50% of the main business, or 50% is not achieved but the building construction revenue and profits are the highest in all the business and occupied to the whole revenue and the complete profits are all more than 30%. The company that occurred holistic listing, reorganization or loss during the study time was rejected. Finally, there are nine listed companies meets the requirements in total, include the Norinco International Co., Ltd., (NI), the Shenzhen Tagen

Group Co., Ltd (SZTG.), the China Nonferrous Metal Industry'S Foreign Engineering And Construction Co., Ltd (CNMIFEC), the Shanghai Construction Group Co., Ltd (SHCG), the CRBC International Co., Ltd (CRBC), the Tengda Construction Group Co., Ltd (TDCG), the China Railway Erju Co., Ltd (CRE), the Shanghai Tunnel Engineering Co., Ltd (SHTE) and the Longjian Road and Bridge Co., Ltd (LJRB). The data are from the CSMAR Database of GTA (www.gtarsc.com) and was not given in the article because of the amount.

Definition of the evaluation index system: The corporate performance reflects the business operating results. The corporate performance evaluation is the comprehensive analysis of productivity and operating activities. The evaluation index system must be in accordance with the principles and requirements for reflecting the overall features of objects.

Although some scholars believe that the usual evaluation index system is problematic. However, some research indicates that the traditional financial performance indicators with the EVA indicators are able to explain each other and the evaluation result used one kind indicators is accordant with used the other. The EVA indicators reflect the profitability and the habitual monetary performance indicators reflect the other ability which the EVA indicator could not replace. Therefore, the evaluation indicators are the conventional financial performance indicators in the article. The selection of the indicator is according to The Enterprise Performance Evaluation Regulations (Revision) which is issued by the Finance Ministry and the other four Ministries. The actuality of the listed company features, the data obtainment and the analysis requirement was considered. Finally, 13 efficiency indicators and one cost indicators were used in the study. The 14 indicators reflect the profitability, the asset quality, debt risk and business growth of the firm.

Enterprise profitability: There is the Rate of Return on Common Stockholders' Equity x_1, Return On Total Assets x_2, Operating Profit Ratio x_3 and Cash Profit Ratio x_4. The four indicators mainly reflect the input-output a period of time.

Enterprise business growth: There are Business Growth Rates x_5, Capital Preservation and Appreciation Rates x_6, Operating Profit Growth Rate x_7 and Total Assets Growth Rate x_8. The four indicators mainly reflect the business development.

Table 1: Average value of performance standards from 2005 to 2007

Rank index	Excellent	Good	Average	Poor	Worse
x_1	16.4	10.8	6.3	-1.5	-8.9
x_2	8.2	5.7	3.4	-0.8	-4.4
x_3	19.9	14.2	8.7	4.7	0.3
x_4	9.3	4.2	1.2	-2.8	-6.3
x_5	32.6	23.4	13.9	2.0	-11.5
x_6	114.8	109.5	104.5	98.8	92.5
x_7	31.3	18.7	9.8	-12.4	-21.6
x_8	22.8	16.6	9.7	-3.8	-13.1
x_9	1.6	1.0	0.7	0.5	0.3
x_{10}	16.6	10.4	6.0	2.9	1.4
x_{11}	3.1	2.1	1.4	0.8	0.5
x_{12}	5.2	3.8	2.6	0.1	-2.3
x_{13}	136.2	104.5	76.8	60.3	43.1
x_{14}	490.0	60.6	72.2	81.9	91.6

Enterprise asset quality: There is the Total Asset Turnover Ratio x_9, Accounts Receivable Turnover Ratio x_{10}, Current Asset Turnover Ratio x_{11}. The three indicators mainly reflect the efficiency of resource use and asset management.

Enterprises debt risk: There are Interest Earned Multiples x_{12}, Quick Ratio x_{13} and Debt Asset Ratio x_{14}. The three indicators mainly reflect the debt repayment capabilities.

Generation of the training data for the model: In order to avoid the subjectivity in the network learning, the training data generate, firstly. The corporate performance constantly changes because the macro-economic and interior factors such as the business strategy and the indicators also change correspondingly. So, the State-owned Assets Supervision and Administration Commission of the State Council of China (SASAC) calculate and enact the annual standard of corporate performance evaluation according to the data information of the State-owned enterprise such as financial position and so on, referring to the monthly report of the State Statistics Bureau of China and the other related statistical data. The yearly standard of corporate performance evaluation was divided into excellent, good, average, poor and worse. In order to eliminate the effect of years, the average value of performance standards from 2005 to 2007 was calculated at first. The calculation is as shown in Table 1.

Considering that the actual corporate performance would be greater or less than the five values, the standard is divided into six ranks, that is rank (greater than excellent), rank (from good to excellent), rank (from average to good), rank (from poor to average), rank (from worse to poor) and rank (less than worse). Five sets of data were generated randomly in each rank, different

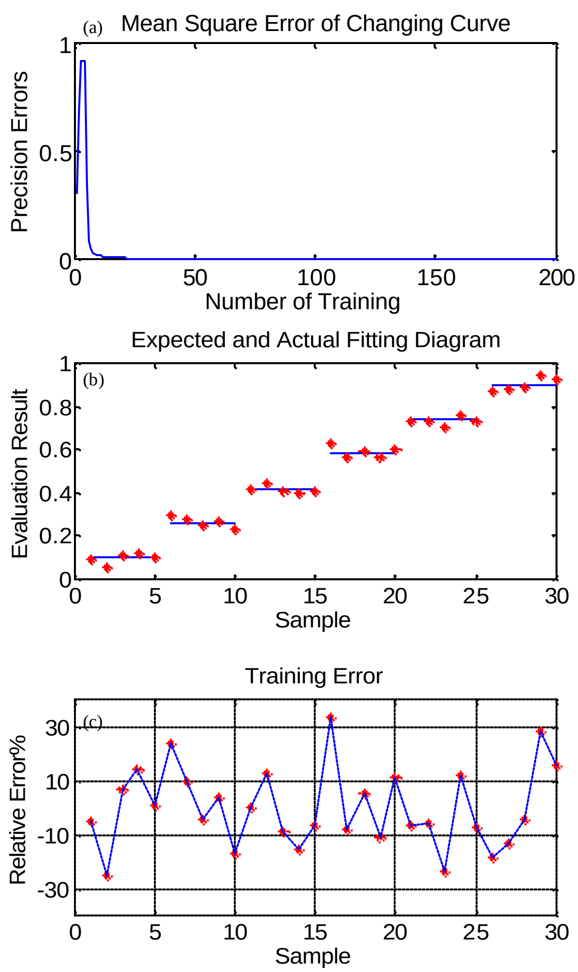

Fig. 2(a-c): Initial results of the training

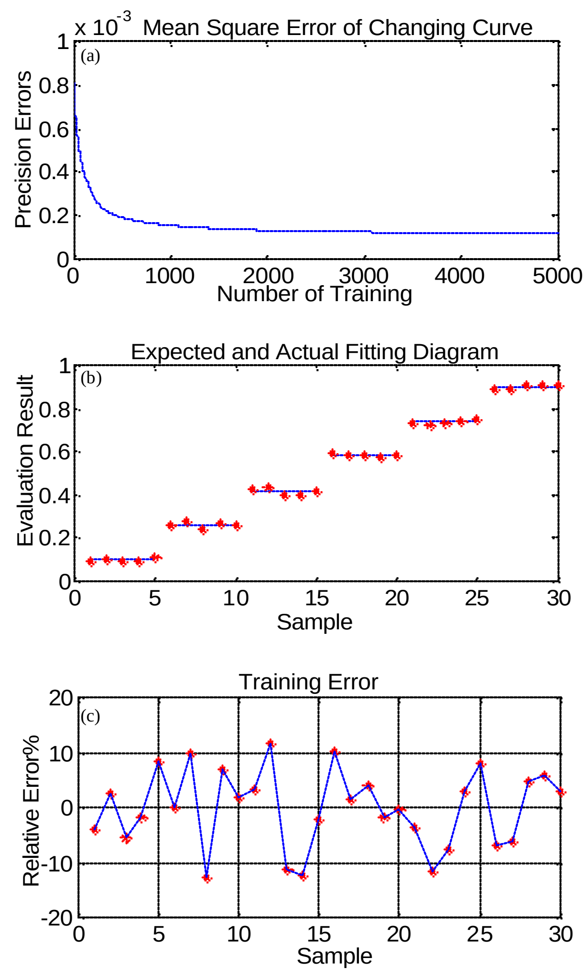

Fig. 3(a-c): Ultimate results of the training

evaluation of expected value was given to different rank (from 0.10 to 0.90). There are 30 sets of data and the corresponding evaluation of expected value in total.

Training of the evaluation model

Normalize the input data: The efficiency indicators x_1~x_{13} were normalized by the Eq. 2a and the cost indicator x_{14} was normalized by the Eq. 2b. The r^i_k is the normalization sample series.

Define the initial network structure and parameters: The amount of input layer nodes m = 14and the amount of output layer nodes is 1. The numbers of hidden layer nodes n are defined by min (14.1)<n≤214+1. The weights and the initial Dilation Coefficient and Translation Coefficient all are decimal of uniform random distribution and the range is $(-3/\sqrt{p}, 3/\sqrt{p})$, p = m??n, n, n, n.

Train sample data and change the network parameters: The sample data were trained according to Eq. 1. The learning rate η was dynamically changed according to the Error Entropy Function which was calculated with the Eq. 3. The v_j, w_{ij}, a_j and b_j was changed according to the grade of weights and coefficient which were calculated with the Eq. 4-8.

The training times are 200 for the different number of hidden layer nodes. The final network structure is 14-21-1 after adjusting repeatedly times. The sample number is 5 that the relative error of the actual value to the expectation is over 20%. It is 16.7% of the total sample number. The results are as shown in Fig. 2.

Then, taking the weights w and v, Dilation coefficient a and Translation coefficient b that gained above as the initial input, the calculating accuracy of the network is improved through the further training. The ultimate network parameters have been getting after approximately 5000 trainings and the duration is 98.92 s. The training results are as shown in Fig. 3.

It could be gained from Fig. 3a that the efficiency of improving the precision gradually became low

Table 2: Evaluation results of some listed construction companies

	2002	2003	2004	2005	2006	2007
NI	0.3136	0.3243	0.5386	0.3157	0.3785	0.1233
SZTG	0.2835	0.3425	0.2260	0.3410	0.3106	0.3335
CNMIFEC	0.4724	0.4472	0.4601	0.4708	0.6751	0.5967
SHCG	0.4658	0.4473	0.4990	0.5501	0.5387	0.5388
CRBC	0.3424	0.3408	0.3781	0.3211	0.3405	0.3832
TDCG	0.3960	0.4750	0.3532	0.3814	0.3045	0.3169
CRE	0.3296	0.3521	0.3906	0.4326	0.5122	0.3850
SHTE	0.3126	0.3049	0.3346	0.2863	0.2566	0.3452
LJRB	0.4463	0.3435	0.2838	0.2946	0.2265	0.2104

accompanying the training times increase. The relative error of the actual value to the expectation which is less than 10% is 90% of the total sample. The comparative error of the actual value to the expectation which is less than 5 percent is about half of the sample. Considering that randomly generated sample, the training precision could meet the distinguishing accuracy of evaluation. So, the network parameters from training were output and the training is over.

Evaluation of the subjects

Normalize the data of subjects' indicators: The efficiency indicators x_1~x_{13} were normalized by the Eq. 2a and the cost indicator x_{14} was normalized by the Eq. 2b. The r^i_k is the normalization subject series.

Comprehensive evaluation: The r'^i_k were input the trained network expert system and the ultimate comprehensive evaluation of the listed construction companies was gained. The results are as shown in Table 2.

Analysis of the results: Firstly, the study sample performance is not good and annually fluctuating. It can be gained from Table 2 that the performance of the samples is all less than the average except for CNMIFEC and SHCG are close to or more than. There are so many building enterprises that the low-level competition is intense and it is the main reason that the performance is poor. The sample's annual performances are all fluctuating and any enterprise's fluctuation is large. The fluctuation of performance results from the characteristics of production in the construction industry, such as the distinction of the products, the numerous influencing factors of cost and price, the un-fixable buyers of the product and so on. It is important to study how to develop the scientific management strategy to offset the above factors influence in the construction business performance.

Secondly, the changing trends of different business performance are inconsistent. It can be gained from Table 2 that some enterprise's performance is on the rise but some enterprise's performance is on the decline though the performances are good, such as TDCG. The difference of trend is related to factors such as the business field. The trends could not be found and the decision-maker would be influenced if the longitudinal dynamic evaluation has not been carried out but only the static evaluation. Therefore, the longitudinal dynamic evaluation has the advantage that the horizontal static evaluation did not have.

CONCLUSION

The study on some listed building enterprises indicated that the wavelet neural network model could evaluate the corporate performance quickly and accurately. The evaluation results shown that the most sample's performances are not good and annually fluctuating. The overall level of enterprise performance has much room for improvement. The changing trends of corporate performance could be found through the dynamic evaluation of time series. It could be found that the trends result from the industry-specific issues or from the specific enterprise through the horizontal inter-firm comparison. It is important for testing the validity of enterprise management and improving the corporate performance.

There is many diversification corporate because the listed companies have the advantage in the capital. The different competition tension would lead to different firm performance because the difference in the industry which the businesses are or in the region where the business is. The industry composition and the regional distribution of the corporate would impact the firm performance greatly. The results may be biased because the study did not consider the above factors. It would be further refined in the future research.

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REFERENCES

Gao, C., Y. Sun, J.Y. Huang and R.R. Wu, 2012. AR and WNN hybrid method for pattern recognition of SME signals. Int. J. Adv. Comput. Technol., 6: 414-421.

Khan, M.A.S. and M.A. Rahman, 2010. A novel Neuro-wavelet-based Self-tuned wavelet controller for IPM motor drives. IEEE Trans. Ind. Appl., 46: 1194-1203.

Li, R.H., J.M. Xu, Q. Luo and S.G. Hu, 2013. Real-time traffic flow forecasting based on wavelet neural network. Int. J. Online Eng., 9: 72-76.

Lin, J. and X.G. Zheng, 2008. The performance evaluation of real estate listed company based on entropy TOPSIS. Technol. Econ. Manage. Res., 4: 14-15.

Lin, L., D.K. Xu and H.J. Wang, 2010. Fault diagnosis of WSNs node based on wavelet neural network. COMPEL: Int. J. Comput. Math. Electrical Electronic Eng., 29: 563-570.

Ma, J.Q., Y. Yang, F. Li, F. Zhang and X. Luo, 2012. Research on an evaluation method of customer collaborative innovation design scheme based on R-A-WNN. Int. J. Adv. Comput. Technol., 4: 298-306.

Tang, W.N. and F.Y. Xu, 2007. Wavelet network comprehensive evaluation method for partner selection in mass customization. Comput. Integrated Manuf. Syst., 13: 400-404.

Wang, X.P., 2008. Evaluation of the performance of Chinese agricultural listed companies. Chinese Agric. Sci. Bull., 24: 531-534.

Yang, J., Y. Yang, W.L. Wang, X.H. Zhao and L.J. Song, 2008. Evaluation of collaborative innovative customer based on PWNN model and its application. Comput. Integrated Manuf. Syst., 14: 882-890.

Yang, J.H., P. Zhao and T.Y. Ma, 2008. Financial assessment of listed companies based on PCA-SOM. J. Jilin Univ. (Inform. Sci. Edn.), 26: 192-198.

Zhang, Q. and A. Benveniste, 1992. Wavelet networks. IEEE Trans. Neural Netw., 3: 889-898.