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Evaluation and predication of ideological and political management performance based on RBF neural network and discriminant technology

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ABSTRACT

To study the internal law and development trend of governments' ideological and political management and operation as well as to predict the level of local governments' ideological and political management performance, RBF neural network and discriminant technology were combined in this paper. Firstly, the evaluation index system for evaluating the performance of ideological and political management and operation was built. Secondly, discriminant analysis was carried out by means of discriminant technology. Finally, a prediction model for ideological and political management was built by using RBF neural network. 11 area samples in Chinese east-central-west regions were used as the study objects to predict and evaluate ideological and political management performance.

KEYWORDS

Discriminant analysis; RBF neural network; Ideology and politics; Performance management; Network structure.



INTRODUCTION

Since reform and opening-up, China has carried out a series of reforms and experiments on ideological and political management system in order to cater to the demands of reform of the economic system. Some progresses and achievements have been achieved. However, it's impossible to accurately and effectively evaluate and predict the performance management level of current ideological and political management organizations, which results in inferior management level and efficiency. It's also impossible to conduct quantitative evaluation. Meanwhile, local ideological and political management lacks of overall planning and macro coordination, which leads to serious resource waste in ideological and political management as well as poor regional cooperation. As a result, the efficiency and work quality of ideological and political management is reduced significantly.

In 2013, Tang Renwu et al. [1] designed a set of evaluation index system for measuring the performance of Chinese provincial ideological and political management departments, in which the study objects were the influence factors affecting the performance of ideological and political management departments.

In 2012, Peng Xueming et al. [2] realized evaluation research on ideological and political management performance based on economic perspective by means of input and output method. They calculated the input and output ratio of ideological and political management, thus quantitatively evaluating the performance level of ideological and political management.

In 2014, Wu Jiannan et al. [3] processed the data of local governments' management performance by using system engineering theory. They determined the index weight as well as the reliability and validity of the evaluation method.

In 2014, Peng Guofu et al. [4] combined qualitative indexes and quantitative indexes. They determined the weight of the evaluation indexes for ideological and political management performance by means of AHP. Finally, they realized quantitative analysis on ideological and political management performance by using fuzzy evaluation method and DEA model.

Based on predecessors' researches, to improve the efficiency of ideological and political management and to improve the evaluation level of ideological and political performance, the quality of ideological and political management was comprehensively examined by using quantitative indexes. The dimensionality of the evaluation indexes for ideological and political management performance was reduced by means of discriminant analysis and PCA analysis. Then the performance evaluation indexes subject to dimensionality reduction served as the input of RBF neural network to build prediction and evaluation model for ideological and political management based on RBF neural network. Empirical analysis was carried out on the study objects of 11 areas in Chinese east-central-west regions. In this paper, researchers provide a new method and basis for decision making for prediction and evaluation on ideological and political management performance.

DISCRIMINANT ANALYSIS

As far as ideological and political management performance is concerned, a discrimination function was acquired by combining with the analysis on evaluation indexes of ideological and political management performance according to the classification results of ideological and political management performance in the previous years. The governments' ideological and political management performance level was predicted and evaluated by using this discrimination function.

Assume that there are g categories ($g > 2$), each category includes n_1, n_2, \dots, n_g groups of samples, each group of samples include p indexes, which can be indicated as $n = n_1 + n_2 + \dots + n_k$. Assume that each group of samples are independent normal random variables, i.e., [5]

$$(X_{1i}^{(k)}, X_{2i}^{(k)}, \dots, X_{pi}^{(k)}) \sim N(\mu^{(k)}, \Sigma^{(k)}) \tag{1}$$

In Equation (1), $\mu^{(k)}$ indicates the expectation of the p variables of the k th category, matrix $\Sigma^{(k)}$ is the covariance matrix corresponding to the p variables of the k th category, if $\Sigma^{(1)} = \Sigma^{(2)} = \dots = \Sigma^{(g)} = \Sigma$, then the sample $X = (X_1, X_2, \dots, X_p)'$ belongs to which category of g categories as discriminated [6].

Similar to the discrimination of the two categories, the Mahalanobis distance between X and the barycenter (average vector) $\mu^{(k)}$ of each category is calculated as follows [7]:

$$\Delta_{(k)}^2 = (X - \mu^{(k)})' \Sigma^{-1} (X - \mu^{(k)}), \quad k = 1, 2, \dots, g \tag{2}$$

If $\Delta_{(j)}^2$ is the minimum, then X belongs to the j th category as discriminated. The estimation equation of mean vector $\mu^{(k)}$ is:

$$\bar{X}^{(k)} = \frac{1}{n_k} \sum_{i=1}^{n_k} X_i^{(k)} \tag{3}$$

The estimation for covariance matrix Σ is:

$$S = \frac{1}{n-g} \sum_{k=1}^g \sum_{i=1}^{n_i} (X_i^{(k)} - \bar{X})(X_i^{(k)} - \bar{X})' \tag{4}$$

$$\bar{X} = \frac{1}{n} \sum_{k=1}^g \sum_{i=1}^{n_k} X_i^{(k)}$$

In Equation (4), the estimation equation of distance $\Delta_{i(k)}^2$ is as shown in Equation (5):

$$d_k(X) = (X - \bar{X}^{(k)})' S^{-1} (X - \bar{X}^{(k)}) \tag{5}$$

For any group of samples X to be discriminated, $d_k(X), k = 1, 2, \dots, g$ can be calculated according to Equation (5), which can be indicated by Equation (6):

$$d_j(X) = \min \{d_1(X), d_2(X), \dots, d_g(X)\} \tag{6}$$

If $d_j(X)$ is the minimum, then sample X belongs to the j th category as discriminated.

RBF NEURAL NETWORK

RBF neural network consists of the output linear layer and the hidden radial basis layer. The radial basis function is Gauss function whose expression is [8-9]:

$$R_i(x) = \exp\left(-\left\|\frac{x - c_i}{\sigma_i}\right\|^2\right), i = 1, 2, \dots, p \tag{7}$$

In Equation (7), x indicates input vector, c_i indicates the center of the i th basis function, σ_i indicates the variance of the i th basis function, p indicates the number of nerve cells, $\|x - c_i\|^2$ indicates the norm of $x - c_i$. In Equation (8), q is the number of output nodes. The structural schematic diagram of RBF neural network is as shown in Fig. 1.

$$y_k = \sum_{i=1}^p w_{ij} R_i(x), k = 1, 2, \dots, q \tag{8}$$

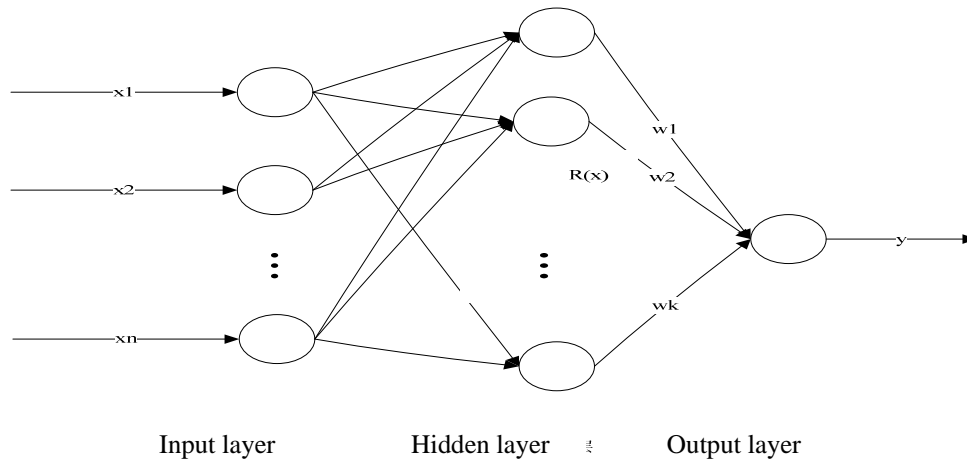


Fig.1 Structure chart of RBF network

EVALUATION INDEXES OF IDEOLOGICAL AND POLITICAL MANAGEMENT

To predict and evaluate ideological and political management performance, firstly, it needs to determine corresponding evaluation indexes. During the process of designing evaluation index system, existing study index system was concluded, and an index system was built based on relevant literatures both home and abroad as well as the actual condition of study and evaluation on ideological and political management in China. The evaluation index system of ideological and political management performance includes three layers of indexes: evaluation objective layer, criterion layer and sub-criterion layer. It is divided into 1 first-level index, 7 second-level indexes, 20 third-level indexes, as shown in Table 1 [10].

Table 1 Table of evaluation indexes of ideological and political management performance

Evaluation index	Classified evaluation index	Individual evaluation index
Evaluation index system of ideological and political management U	Performance index of education undertaking management U_1	X_1 proportion of education undertaking expenses accounting for GDP (%)
		X_2 number of full-time teachers of every 100 students (person)
		X_3 gross enrollment rate of undergraduates (%)
	Performance index of science and technology undertaking management U_2	X_4 proportion of public expenditure for R&D accounting for GDP (%)
		X_5 number of patent applications (piece)
	Performance index of cultural undertaking U_3	X_6 per capita book collection in public library (book)
		X_7 Radio Coverage of Population (%)
		X_8 TV Coverage of Population (%)
	Performance index of health undertaking management U_4	X_9 proportion of expenditure for public health undertaking accounting for GDP (%)
		X_{10} number of hospital beds for every a million persons (piece)
		X_{11} number of doctors for every ten thousand persons (person)
	Performance index of social security undertaking U_5	X_{12} proportion of expenditure for social security accounting for GDP (%)
		X_{13} headcount of people eligible for social relief (person)
		X_{14} number of adopting and resettling organizations of social and welfare services (unit)
	Performance index of environmental protection undertaking U_6	X_{15} proportion of city maintenance cost accounting for GDP (%)
		X_{16} the rate of multipurpose utilization of solid waste (%)
		X_{17} industrial wastewater discharge compliance rate (%)
	Performance index of infrastructure construction U_7	X_{18} per capita area of road (m^2)
		X_{19} per capita length of subdrainage pipe (m)
		X_{20} per capita area of landscaping (m^2)

EMPIRICAL ANALYSIS

Data source

Typical cities in Chinese east-central-west regions were selected. 11 regions of Beijing, Shanghai, Guangzhou, Chongqing, Chengdu, Harbin, Wuhan, Suzhou, Hangzhou, Shijiazhuang and Xining were selected as the objects for empirical analysis^[11-12]. The data in this paper were sourced from *China Statistical Yearbook* and local statistical yearbooks. In this paper, the data of ideological and political management performance levels in each region from 1995-2014 were used

as study objects. There were 20 groups of data in total. The 20 groups of data were divided into two parts. The first 16 groups of data were training samples, while the remained 4 groups of data were testing samples.

Discriminant analysis

The evaluation indexes of the ideological and political management performance of 11 typical local governments in Chinese east-central-west regions were the independent variables. The number of independent variables was 23 ($X_1 \sim X_{23}$). The ideological and political management performance levels were defined as 5 ratings of excellent, good, middle, bad and very bad. The results of discriminant analysis are as follows:

$$F_1 = 0.791x_1 + 0.873x_2 - 3.112x_3 \dots + 2.785x_{23} - 6.483$$

$$F_2 = 2.221x_1 + 0.681x_2 + 0.925x_3 \dots + 1.783x_{23} - 4.212$$

Taking Hangzhou as an example, the calculation result of its ideological and political management performance in 2013 is $F_1 = 8.98, F_2 = 0.65$. It is excellent rating. Based on this, Hangzhou’s ideological and political management performance level in 2013 is discriminated as excellent.

PCA analysis

Statistical test

Assume the significance level is 0.05. The data selected are subject to KMO and Bartlett’s test of sphericity. The test results as shown in Fig. 2.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.604
Bartlett's Test of Sphericity	Approx. Chi-Square	56.843
	df	28
	Sig.	.001

Fig. 2 KMO and Bartlett’s tests of sphericity

According to Fig. 2, the statistics of KMO is $0.604 > 0.5$, the statistics of Bartlett’s test of sphericity is 56.843, the significance probability is $0.001 < 0.05$. So the null hypothesis of Bartlett’s test of sphericity is refused. Therefore, the index data affecting ideological and political management performance are comparatively suitable for PCA analysis.

Determining the common factors

According to the standard of characteristic value > 1 , accumulative contribution rate exceeding 80%, the PCA extraction results are as shown in Fig. 3:

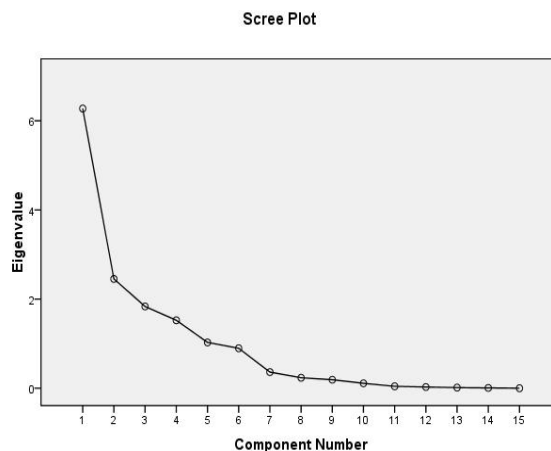


Fig. 3 Scree Plot

According to Fig. 3, the characteristic curve in the scree plot has a turning point at factor 5. Therefore, the common factors should be extracted from the first five factors. According to Table 2, among the 5 factors whose characteristic value is > 1, the accumulative contribution rate of the first 4 factors is 80.571%>80%. This shows that these 4 factors can well reflect the level of ideological and political management performance.

Table 2 The characteristic value of relevant matrix R

	Initial characteristic value			The characteristic value after extracting the 4 factors and orthogonal rotation		
	Eigenvalue	Proportion	Cumulation	Eigenvalue	Proportion	Cumulation
1	6.274	41.829	41.829	5.278	35.189	35.189
2	2.453	16.352	58.181	2.477	16.511	51.700
3	1.834	12.227	70.408	2.462	16.413	68.112
4	1.525	10.164	80.571	1.869	12.459	80.571
5	1.028	6.853	87.424			
6	0.897	5.977	93.402			
7	0.597	6.599	100			

Building factor loading matrix

The factor loading matrix is calculated by using varimax rotation, the calculation results are as shown in Table 3:

Table 3 Factor loading matrix

	Component			
	1	2	3	4
U_1	.926	-.084	.058	-.183
U_2	.914	-.197	.187	.204
U_3	.906	.142	.227	.059
U_4	.901	-.129	.220	.270
U_5	.881	.359	.171	.002
U_6	.215	.888	.184	.060
U_7	-.437	.758	-.060	.375

Calculating factor score

Table 4 Factor score matrix

	Component			
	1	2	3	4
U_1	.170	-.039	-.018	.120
U_2	.047	-.052	-.470	.087
U_3	.180	.150	-.021	-.019
U_4	.212	-.031	-.114	-.121
U_5	.090	-.031	.094	-.327
U_6	-.017	-.023	.020	.252
U_7	.145	-.118	-.295	.356

According to Table 4 factor score matrix, the linear calculation model of the scores of each factor can be built as follows:

$$F_1=0.170U_1 + 0.047U_2 + \dots - 0.017U_7$$

$$F_2= - 0.039U_1 - 0.052U_2 + \dots - 0.118U_7$$

$$F_3= - 0.018U_1 - 0.470U_2 + \dots - 0.295U_7$$

$$F_4 = 0.120U_1 + 0.087U_2 + \dots + 0.356U_7$$

Based on the contribution rates of the common factors in the variable variance in Table 2, the mathematical evaluation mode of English translation ability can be inferred as:

$$F = 0.35189F_1 + 0.16511F_2 + 0.16413F_3 + 0.12459F_4$$

Predication of ideological and political performance based on RBF neural network

The aforesaid discriminant analysis results were used as input of RBF neural network, and the level of ideological and political management performance was the output. The levels of ideological and political management performance included 5 ratings^[13-14]. Therefore, they were defined as Excellent [1 0 0 0], Good [0 1 0 0], Middle [0 0 0 1 0], Bad [0 0 0 1 0], Very bad [0 0 0 0 1]. The prediction results are as shown in Fig. 3 and Fig. 4.

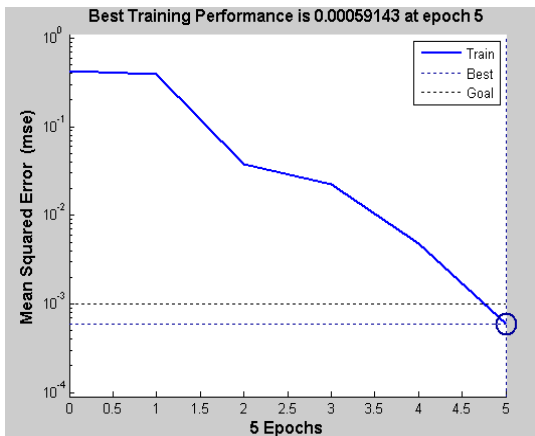


Fig. 3 Error convergence diagram

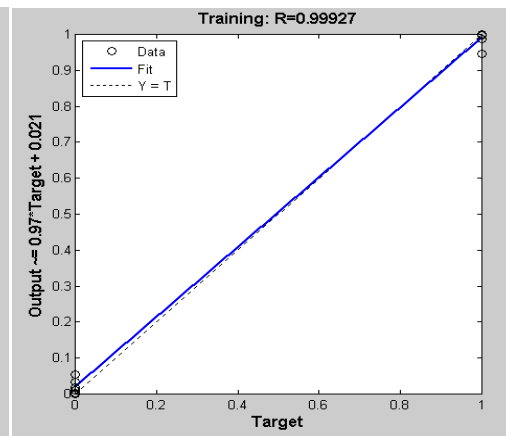
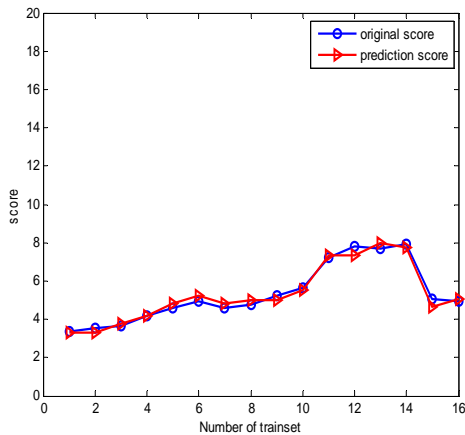


Fig. 4 Fitting diagram

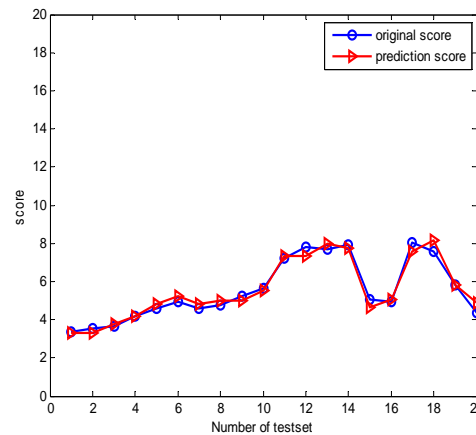
According to Fig. 3 and Fig. 4, predicting the level of ideological and political management performance by using RBF neural network has good effects. Its adjustment coefficient is $R = 0.99927$, which is approximately equal to 1 and close to linear prediction.

Evaluation on ideological and political performance

According to the discriminant analysis results, the scores of discriminant analysis were used as the basis of quantitative evaluation for the level of ideological and political management. The 23 evaluation indexes for ideological and political management performance were used as the input of RBF neural network. The scores of discriminant analysis were used as the output of RBF neural network. The 20 groups of data were divided into two parts. The first 16 groups of data were training samples, while the remained 4 groups of data were testing samples. The simulation results are as shown in Fig. 5 and Fig. 6.



(a) Training result



(b) Testing result

Fig. 5 Training and testing results

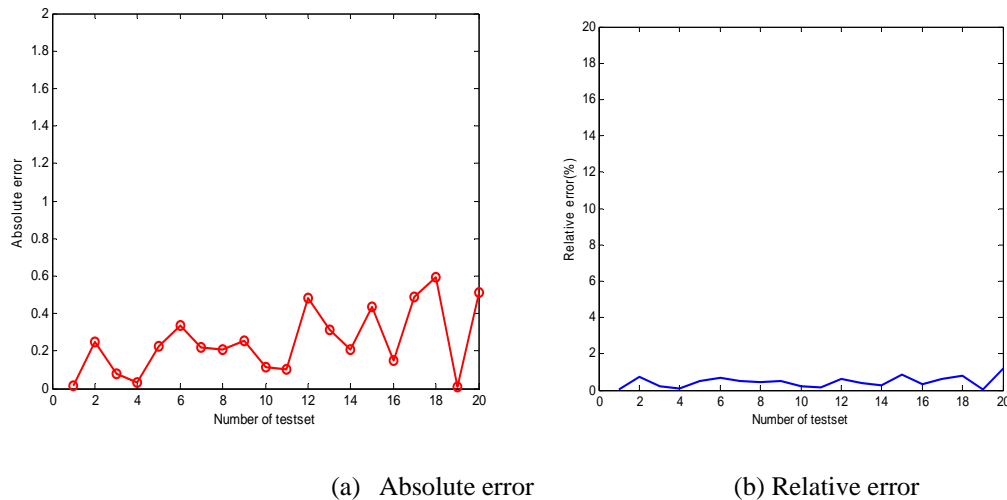


Fig. 6 Prediction errors

According to Fig. 5 and Fig. 6, evaluation on ideological and political management performance by using RBF neural network has good evaluation effects. Its relative error of prediction is less than 5% on average, which contributes to a high precision, thus providing a new method and basis for evaluation on ideological and political management performance.

CONCLUSION

Given the fuzziness in evaluation contents and uncertainties in evaluation scope of ideological and political management performance, discriminant analysis technologies and RBF neural network algorithm were combined in this paper. An evaluation index system was built according to the characteristics of the study objects. Then ideological and political management performance was predicted and evaluated by using the sound nonlinear evaluation ability of RBF neural network. This paper provides a new method and approach for evaluating ideological and political management performance.

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