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A New Risk Forecasting Model of Financial Information System Based on Fitness Genetic Optimization Algorithm and Grey Model

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The problems of security and risk are the main obstacles for the development of electronic bank. Along with the gradual advance of modernization about bank business, based on the existing financial risk, the risk of information system is added and close to the business of electronic bank. The business of electronic bank differing with that of tradition bank is a combination of information technology and electronic commerce. Therefore, the risk of its business is related to the level of information technology, information systems and the conditions of hardware equipment. In this paper, genetic algorithm is introduced to optimize corresponding parameters of grey forecasting model and then the improved grey model can be used in early warning of the risk in the information system of bank. Qualitative and quantitative forecasting methods are combined with grey model to obtain predicted value of risk index of the bank's information system. Finally, the result of experiment states that the proposed method is reliable and exact to promote the development of business in electronic bank in the future.

1. Introduction

Electronic bank always suffers with the problems of security and risk. The business of electronic bank differing with that of tradition bank is a combination of information technology and electronic commerce. Therefore, the risk of its business is related to the level of information technology, information systems and the conditions of hardware equipment. If the supervision mechanism of electronic bank is the same as the traditional one, it will become difficult for the supervision of risk in electronic bank. Therefore, it is also difficult for Banking Regulatory Commission to assess and supervise the risk of electronic bank.

There are many existing studies on assessment of risk in electronic bank. Long et al. (2008) first divided the risks of electronic bank into internal risk and external risk and used fuzzy comprehensive evaluation method to assess the internal risk. For three main risks including the risks of laws, market and operation, Li (2001) evaluated these three risks and proposed corresponding suggestion. Fuzzy logic method is applied by Maher et al. (2008) to assess the security of electronic bank, which is based on fuzzy logic system and IF-THEN operation. According to the framework of COBIT, Guan (2009) developed a classified management method of electronic bank to evaluate its risk. This method achieved a satisfactory result. Fuzzy comprehensive evaluation method as a famous tool is also used by Wang (2009) to evaluate the risk of electronic bank and propose some corresponding measures to prevent its risk. Welch (1999) defined risk management and researched it of electronic bank. Lian (2007) stated that data stream has five levels including application layer, middleware, database management, operation system and network which may affect information security. Then, hierarchy method should be introduced to assess the model. Sulivan (2000) developed the impact of electronic bank on traditional bank and analyzed this impact from the perspectives of acceptability and risk. The risk of coffers in electronic bank is proposed by Spivey (2001).

In practice, the application of data in electronic bank is always not exact. Therefore, the early warning of the risk in electronic bank should be exact to guarantee corresponding benefits. Grey model has been widely applied in this field (Jiang, 2004; Lee 1986; Lin and Yang, 2003; Tien, 1996; Liu et al, 2001, Jie et al, 2004). Deng (2009) first proposed grey system theory to deal with incomplete data. Then, this method is developed by Liu et al.

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(2010) to form a way of addressing corresponding information. However, there are few existing studies about early warning of the risk in electronic bank.

Therefore, in this paper, genetic algorithm is introduced to optimize corresponding parameters of grey forecasting model and then the improved grey model can be used in early warning of the risk in the information system of bank. Qualitative and quantitative forecasting methods including expert scoring and mathematic modeling are introduced. First, based on the real case of the business in electronic bank, an attribute system is constructed. Then, different experts provide corresponding score on each attribute according to their preference, which will be normalized and then considered as samples. Moreover, grey model with genetic algorithm is proposed to forecast the risk of information system in electronic bank to obtain corresponding risk value. Finally, the result of experiment states that the proposed method is reliable and exact to promote the development of business in electronic bank in the future.

2. Grey model

Grey system theory is proposed by Deng to firstly develop a method used to manipulate data where partial information is known. Then, we will review some basic concepts of positive accumulated generation operator and regressive generation operator.

The initial series is given as $X^{(0)} = \{x^{(0)}(1), x^{(0)}(2), \cdots x^{(0)}(n)\}$, where n is dimension, $X^{(0)}$ is grey series and $n \geq 1, x^{(0)}(i) \geq 0$.

Then we redesign new series $X^{(1)} = \{x^{(1)}(1), x^{(1)}(2), \cdots x^{(1)}(n)\}$, where

$$x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i) \tag{1}$$

$X^{(1)}$ is one positive accumulated generation series of $X^{(0)}$. That is, $X^{(1)} = AGOX^{(0)}$. If r positive accumulation is applied based on equation (1), it can be obtained that $x^{(r)}(k) = \sum_{i=1}^{k} x^{(r-1)}(i)$.

If $x^{(0)} = x^{(1)}(k) - x^{(1)} \cdot (k-1)$, $X^{(1)}$ is one positive regressive generation series of $X^{(0)}$. That is, $X^{(1)} = IAGOX^{(0)}$. If r positive regression is applied based on equation (1), it can be obtained that $x^{(r-1)} = x^{(r)}(k) - x^{(r)} \cdot (k-1)$.

3. Genetic algorithm

In general, genetic algorithm can be used to assess corresponding parameters a and b, the detailed process is demonstrated as follows:

step 1, binary coding. We first determine the threshold of developing coefficient a and grey action criterion b. Then, genetic algorithm is used to code a and b to acquire the initial population which is the demand of genetic algorithm.

step 2, construction of fitness function. The terminal condition of finding optimization parameter depends on the value of fitness function judged by us. If this value accords with the demand of us, prediction accuracy of grey model reaches the request. Meanwhile, this genetic algorithm can be terminated. Thus, parameters a and b are the optimization values after the process of decoding. Then these optimization parameters can be applied to the process of modeling the grey forecasting model. However, if the fitness value does not reach the request, we can go to the step 4.

Value of fitness degree of genetic algorithm can be measured by the following equation.

$$MSE = \frac{1}{N} \sum (x_i - \hat{x}_i)^2 \tag{2}$$

x_i Is the real value, $\hat{x}_i$ is the prediction value, and N is the total number of samples. The smaller vale the result is, the more exact the genetic algorithm is.

When fitness is lower than average fitness, performance of this individual is not good. Thus, the major crossover rate and mutational rate are adopted, and vice versa. That is, when the value of fitness is closer to the biggest one, the crossover rate and mutational rate are smaller. Especially, when the value of fitness equals to the biggest one, the crossover rate and mutational rate equals to zero. This method is more suitable

for the later evolution of population. Ai that time, the performance of each individual in population is good and thus it is not suitable for changing individual to break this good performance.
Therefore, in this paper, genetic algorithm is improved adaptively and he crossover rate and mutational rate are demonstrated in the following.

$$p_c = \begin{cases} p_{ci} - \dfrac{p_{ci} - p_{cj}}{f_{\max} - f_{avg}}(f' - f_{avg}) & f' \geq f_{avg} \\ p_i & f' < f_{avg} \end{cases} \tag{3}$$

$$p_m = \begin{cases} p_{mi} - \dfrac{p_{mi} - p_{mj}}{f_{\max} - f_{avg}}(f_{\max} - f) & f \geq f_{avg} \\ p_i & f' < f_{avg} \end{cases} \tag{4}$$

step 3, calculation of fitness function. Based on the application of proposed algorithm in the risk assessment system of electronic bank and the preference of risk, we reset the parameters as follows.
Suppose the size of population (M = 200), the number of terminal evolution (T = 50), the bigger crossover rate (Pc=0.975), the smaller mutational rate (Pm=0.001).
step 4, selection, crossover and mutation. Through the selection, crossover and mutation of genetic algorithm, the population can be obtained. Then we can go to step 2 to judge the value of fitness.
As the mentioned algorithm, the estimated value of the important parameters *a* and *b* can be acquired.

4. Numerical example and result analysis

Firstly, based on the existing reference, 5 experts which are from different fields including computer, finance and management are invited to give 9 attributes. Then, they provide the score of the risk about electronic bank on each attribute demonstrated in Table 1. Because of the limitation of content, the data of 2012 and 2013 is omitted.
Then according to the comments in Table1, we get the normalized three-level index evaluation matrix $L = (L_{ij})$. Multiply three-level attribute evaluation matrix and three-level attribute comprehensive weights to have three-level attribute evaluation results. Based on $E_i^j = T_i^j \cdot V$, the V = {90,80,70,60,50}, we can calculate the risk assessment indexes of the 9 two-level index layers from 2011 to 2012. The i means indicators content and i = 1,2,…,9.
We get a and b which are the background parameters of optimized gray forecasting model. According to the degree of their impact on results, MATLAB is used to obtain parameters 0.031124 and 13411.2135.
Based on the above risk attributes, the gray forecasting model will be used to forecast the risk assessment indexes of the next four periods: the first half and the second half of 2014 and 2015 showed in Table 3.
Through comparison the result with the practical situation, to a large extent electronic bank realizes virtualization. But it leads to major increase of risk about business of electronic bank, management risk, especially, the selection risk of internet technology and artificial risk. It is further demonstrated that this work depends on artificial operation and need maintenance and management of bankers. Therefore, the essential supervision and inspection of business and management can decrease these risks. This system of supervision and inspection can be divided into three levels. First, the main work is to inspect whether some countermeasures are used to comply with the corresponding laws and regulations. Meanwhile, essential disclosure must be executed to advertise non deposit investment instruments. Second, agreement between bank and some relevant person such as clients and technology vendors must be inspected that whether it provides corresponding power and obligation. Then, it must be inspected that whether the laws of digital signature and authentication institutions are considered and an agreement between bank and a third party is included in corresponding documents. Thirdly, it must be inspected that whether corresponding confidentiality agreement is set to determine burden sharing. Because risks of control, operation responsibility and conflict overseas are less impact on the bank system, its risk attribute becomes level off.

Table 1: Technical risk evaluation results of electronic banks

1st grade	2nd grade	3rd grade	Comment	The first half of 2011		The second half of 2011	
				Score	Normalization	Score	Normalization
The risk of electronic bank	**Organization risk**	**Planning and organization**	Excellent	3	0.6	1	0.2
			Good	2	0.4	4	0.8
			General	0	0	0	0
			Qualified	0	0	0	0
			Unqualified	0	0	0	0
		The development strategy of business	Excellent	0	0	1	0.2
			Good	3	0.6	4	0.8
			General	2	0.4	0	0
			Qualified	0	0	0	0
			Unqualified	0	0	0	0
		The risk management of electronic bank	Excellent	1	0.2	1	0.2
			Good	2	0.4	4	0.8
			General	2	0.4	0	0
			Qualified	0	0	0	0
			Unqualified	0	0	0	0
	Management risk	**information security management of electronic bank**	Excellent	0	0	1	0.2
			Good	5	1	4	0.8
			General	0	0	0	0
			Qualified	0	0	0	0
			Unqualified	0	0	0	0
		Security strategy	Excellent	1	0.2	1	0.2
			Good	4	0.8	4	0.8
			General	0	0	0	0
			Qualified	0	0	0	0
			Unqualified	0	0	0	0
		Human resource management	Excellent	0	0	2	0.4
			Good	5	1	3	0.6
			General	0	0	0	0
			Qualified	0	0	0	0
			Unqualified	0	0	0	0
	Control risk	**Internal control organization of electronic bank**	Excellent	2	0.4	1	0.2
			Good	3	0.6	4	0.8
			General	0	0	0	0
			Qualified	0	0	0	0
			Unqualified	0	0	0	0
		The control to service provider	Excellent	1	0.2	1	0.2
			Good	4	0.8	4	0.8
			General	0	0	0	0
			Qualified	0	0	0	0
			Unqualified	0	0	0	0
		Audit of electronic bank	Excellent	0	0	1	0.2
			Good	5	1	4	0.8
			General	0	0	0	0
			Qualified	0	0	0	0
			Unqualified	0	0	0	0

Table 2: The risk assessment index

	$j=1$	$j=2$	$j=3$	$j=4$	$j=5$	$j=6$
E_1^j	81.703	82	84.851	84.561	85.703	89.280
E_2^j	80.652	82.438	84.032	82.000	84.000	88.652
E_3^j	82.331	82.000	84.000	83.851	84.830	88.000
E_4^j	82.614	80.693	85.141	82.000	84.000	88.000
E_5^j	82.661	82.911	84.854	87.145	84.855	89.517
E_6^j	81.232	82.000	84.000	86.927	85.232	88.000
E_7^j	82.236	82.407	84.636	86.565	84.000	88.734
E_8^j	80.239	82.000	84.470	82.000	84.000	88.239
E_9^j	80.000	83.382	81.379	82.000	84.000	88.000

Table 3: The prediction results

	The first half of 2014	The second half of 2014	The first half of 2015	The second half of 2015
E_1^j	82.15	89.46	90.21	88.25
E_2^j	82.27	88.46	87.26	86.42
E_3^j	84.43	90.35	90.24	89.65
E_4^j	87.42	85.21	85.33	89.21
E_5^j	83.21	87.31	87.24	90.13
E_6^j	85.18	85.57	88.17	89.34
E_7^j	86.44	85.28	87.21	86.42
E_8^j	87.62	84.61	88.13	87.59
E_9^j	86.44	85.14	86.32	89.56

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