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ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 12 (23): 7636-7640, 2013
ISSN 1812-5638 / DOI: 10.3923/itj.2013.7636.7640

Enterprises Loan Demand Prediction Based on Grey Markov Model Research

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Abstract: This research introduces the concept of the satisfaction degree of small and medium-sized enterprises' financing demands and predicts SMEs' demand satisfaction degree by building the grey Markov model which combines the advantages of grey prediction and Markov prediction model. The analysis of this research reveals the variation trend of SMEs financing demands' satisfaction degree. Markov prediction model identifies the transition of SMEs financing demand satisfaction degree and therefore improve the prediction accuracy and veracity. The empirical analysis concludes that the funds market does not meet the SMEs' financing demands in the long term and based on the result, this paper provides applicable recommendations.

Key words: Grey GM(1,1) prediction, Markov prediction model,medium-sized and small enterprises, financing demands, satisfaction degree prediction

INTRODUCTION

Credit financing demand forecast can be described that bank predicts future credit financing demand of SMEs based on collected information of the enterprises. The purpose is to satisfy credit financing demand of SMEs (Osei-Assibey *et al*., 2012). Because financing mode for small and medium-sized enterprise is relatively sole, credit financing becomes a main measure (Atherton, 2012; Liu and Li, 2003; Akterujjaman, 2010). At present, there are a variety of methods for demand forecast. Angelini predicts enterprise financing demand by using a series of interviews which is a method of qualitative prediction (Angelini *et al*., 1998). The other quantitative prediction methods are linear prediction, exponential smoothing prediction, logistics demand Forecast, a set of model prediction, gray prediction and so on (Chen *et al*., 2009). Gray prediction is a forecasting method that translates time series into differential equation (Liu and Xie, 2008; Zhang, 2010). It can solve uncertainty of small simple and poor information. Through investigating above literature, a few methods of SMEs credit financing demand forecast have been found. Traditional forecasting method does not consider actual situation that enterprises credit financing demand will be after-affected.

In order to release after-affect property, the paper introduces Markov forecasting Model (Liu, 2004). SMEs credit financing demand will be affected by internal and external environment system. Meanwhile, SMEs credit financing demand forecasting is affected by a large number of factors and it cannot be measured accurately. With regard to decrease other impact, it adopts satisfaction forecasting indicator for credit financing demand to reflect SMEs credit financing demand prediction. The reason of using satisfaction indicator for credit financing demand is that there is different credit financing demand among different enterprises and industries. Markov forecasting model is confirmed to be feasible that SME credit financing demand in present period is correlated with that in next period, but less correlated with that in future period.

This research introduces the concept of the satisfaction degree of SMEs ' financing demands, predicts SMEs' demand satisfaction degree by building the grey Markov model and measures banks satisfaction degree for SMEs' credit financing demand by using satisfaction degree of credit financing demand which combines the advantages of grey prediction and Markov prediction model. The analysis of this research reveals the variation trend of SMEs financing demands' satisfaction degree. Markov prediction model identifies the transition of SMEs financing demand satisfaction degree and provides scientific accordance for decision making of credit funds arrangement.

GREY MARKOV MODELING

In order to construct Grey Markov model, the understanding of SMEs' credit financing demand is a start. There is a two-step modeling way. Firstly, taken a

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Grey forecasting model, it is suitable for solving the shortage of SMEs' information. Secondly, taken a Markov model, it is effective for solving instability of SMEs' production and sale environment and meeting the credit financing demand.

Construct Grey GM(1,1) forecasting model with time series: Satisfaction degree of SMEs' credit financing demand is measured as a ratio of supply and demand of credit funds. Assume only a bank satisfies all SMEs' credit financing demand and the amount of credit funds application can be instead by the whole demand. Original data sequence of satisfaction degree of SMEs' credit financing demand $X^{(0)} = (x^{(0)}(1), x^{(0)}(2),\ldots X^{(0)}(n))$ is a set of grey variables with incomplete information which has great randomness, $X^{(0)}$ is a non-negative factor. Through processing first-order accumulation, a new sequence of satisfaction degree of SMEs' credit financing demand $X^{(1)} = (x^{(1)}(1), x^{(1)}(2),\ldots x^{(1)}(n))$ can be obtained. The mathematical equation is expressed as:

$$X^{(1)}(k) = \sum_{m=1}^{k} x^{(0)}(m)\, k=1,2,\ldots n \tag{1}$$

Based on above sequence, the data is fitted by using dynamic linear model.GM equation of forecasting model is expressed as:

$$X^{(0)}(k) + ak^{(1)}(k) = b \tag{2}$$

The whitening equation (the equation of satisfaction degree of SMEs' credit financing demand) is:

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = b \tag{3}$$

In the formula, a b are specific parameters, a is development coefficient of satisfaction degree of SME credit financing demand, b is grey action. A reflects development trend of satisfaction degree of SMEs financing demand, b reflects endogenous control gray number, the size of b reflects data variation relationship of satisfaction degree of SMEs credit financing demand. After taken data sequence of $X^{(1)}$ into grey process, generated $Z^{(1)}$ is the mean of $X^{(1)}$next sequence. $Z^{(1)} = (z^{(1)}(1), z^{(1)}(2),\ldots z^{(1)}(n))$ and:

$$Z^{(1)}(k) = \frac{1}{2}\left[x^{(1)}(k) + x^{(1)}(k-1)\right]\ k = 2,3,\ldots n \tag{4}$$

Assume â is undetermined Parameter vector, the result can be obtained by using least square method:

$$\hat{a} = \begin{bmatrix} a \\ b \end{bmatrix} = (B^T B)^{-1} B^T Y_n \quad n=2,3,\ldots \tag{5}$$

In the formula:

$$Y_n = \begin{bmatrix} x^{(0)}(2) \\ \ldots\ldots \\ x^{(0)}(n) \end{bmatrix}$$

$$B = \begin{bmatrix} -\frac{1}{2}z^{(1)}(2) & 1 \\ -\frac{1}{2}z^{(1)}(3) & 1 \\ \ldots & \ldots \\ -\frac{1}{2}z^{(1)}(n) & 1 \end{bmatrix}$$

After solving differential Eq. 3, satisfaction degree forecasting model GM(1,1) of SMEs financing demand can be obtained:

$$x^{(1)}(k+1) = (x^{(0)}(1) - \frac{b}{a})e^{-ak} + \frac{b}{a}\ k = 1,2,3,\ldots,n \tag{6}$$

The result can be obtained from Eq. 1:

$$x^{(1)}(k+1) = x^{(1)}(k) + x^{(0)}(k+1)$$

The variation trend of original data sequence $x^{(0)}$ in satisfaction degree of SME credit financing demand is decrease progressively:

$$x^{(0)}(k+1) = (1-e^{a})(x^{(0)}(k) - \frac{b}{a})e^{ak}\ k = 1,2,3,\ldots,n \tag{7}$$

Assume:

$$\hat{y}(k) = x^{(0)}(k+1),\ \hat{y}(k)$$

n GM(1,1)model is predictive value for satisfaction degree of SMEs credit financing demand on k point. The curve $x^{(0)}(k+1)$ reflects entire variation trend of original data sequence for satisfaction degree of SME credit financing demand.

Construct Markov prediction model

The assumption based on Markov Chain prediction model: In order to make the Markov model more accurate and persuasive, some assumptions of this model are presented before it is constructed.

- Any SME credit financing demand belongs to one of the three statuses in certain period of time. Three

statuses are fully satisfied, satisfied and non-satisfied which can be described as S = (S_1, S_2, S_3). Satisfaction degree of SME credit financing demand on t_i point is irrelevant with that on t_i point. Therefore the satisfaction degree of SMEs credit financing demand has non-aftereffect property

- Assume that the number of SMEs remain unchanged during the study
- Assume that all the credit funds of SMEs are obtained from one bank

Construction process of Markov model: The change process of satisfaction degree of SMEs credit financing demand is a non-stationary and stochastic dynamic process that has a random upward or downward trend. SMEs can only remain in one of the three states S_i. With the development of time, SMEs will turn into state S_j by transition probabilities P_{ij} at the next moment t+1.

Status division: According to the characteristics of the Markov model and the above model assumption, satisfaction degree of SMEs credit financing demand is divided into three types which are fully satisfied, satisfied, not satisfied. They are expressed as S_1 S_2 and S_3 .The level of demand for credit funds for SMEs decides the status. We assume that the financing demand of SMEs credit satisfaction is divided into three intervals as followed: (0, W_1) (W_1,W_2) (W_2,+8).The corresponding three states are S_1 S_2 and S_3.

Determination of SMEs Credit financing demand transfer matrix: Assume that the original sample number for SMEs' credit financing demand status transfer from S_i to S_j by M steps is M.The status is S_i and the occurred number is M_i, So the transition probability transfer from S_i to S_j by M steps is P_{ij}.:

$$p_{ij}(q) = \frac{M_{ij}(m)}{M_i} \quad m = 1, 2, 3, \ldots, t \tag{8}$$

P_{ij} is a number set,where the variation region of i and j is a set of finite or infinite integers,P_{ij} is a probability of some system that transfer from status i to status j and it satisfy the equation:

$$P_{ij} \geq 0, \sum_j P_{ij} = 1$$

The SMEs Credit financing demand transfer matrix is:

$$p(m) = \begin{bmatrix} p_{11}(m) & p_{12}(m) & \ldots & p_{1t}(m) \\ p_{21}(m) & p_{22}(m) & \ldots & p_{2t}(m) \\ \ldots & \ldots & \ldots & \ldots \\ p_{n1}(m) & p_{t2}(m) & \ldots & p_{tt}(m) \end{bmatrix} \tag{9}$$

So P(m) is a transfer matrix to reflect the transfer rule among various state of the system. Analysis of transfer state can predict the future trends of SMEs credit financing demand.

SMEs credit financing demand forecast: Based on grey prediction and Markov prediction model, we can determine the future transfer status of uncertain system P_{ij} and determine prediction interval $w_i = [w_{1i}, w_{2i}]$, Then use the median of interval as a predicted value of the future prediction target:

$$\hat{y}'(k) = \frac{1}{2}(w_{1k} + w_{2k}) \tag{10}$$

Based on the predicted value and the actual value of the test, we can determine the accuracy of prediction which is accuracy of prediction of the model. The method to predict accuracy is a comparison method.

SIMULATION EXPERIMENT OF SATISFACTION DEGREE OF SMEs CREDIT FINANCING DEMAND

Assume the quantity of credit fueling of SMEs as the quantity of SMEs which get Credit financing and the SMEs in production funds (Fig. 1). According to satisfaction degree of SMEs credit financing demand (Fig. 2), we can get the data of degree of SMEs credit financing demands from 2005 to 2011 as Fig. 1. It can be seen that satisfaction degree of SMEs credit financing demand in a commercial bank is volatility and randomness. This article adopts original data of satisfaction degree of SMEs credit financing demand from 2004 to 2011, uses the gray Markov model to predict the SMEs credit financing demand from 2008 to 2011 and makes a comparison with the actual data of satisfaction degree of SMEs credit financing demand from 2008 and 2011 on Figure 1 to verify the rationality of this model.

Construct grey GM(1,1) prediction model: According to gray prediction formula(1)~(7) of satisfaction degree of

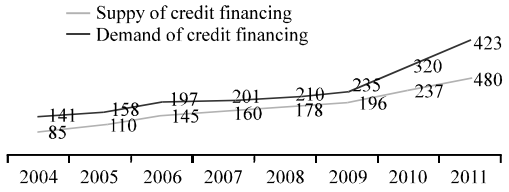

Fig. 1: Supply and demand of SMEs credit financing

Table 1:Grey GM(1,1) Predicted values of satisfaction of SMEs credit financing demands

Year	Actual value	Satus	The value of GM(1,1) model prediction	The difference of prediction value	Accuary (%)
2004	0.6	S_1			
2005	0.7	S_2	0.769028	-0.07	-9.47
2006	0.74	S_2	0.766	-0.03	-3.91
2007	0.8	S_3	0.762983	0.03	4.33
2008	0.85	S_3	0.759979	0.09	11.53
2009	0.83	S_3	0.756986	0.08	10.18
2010	0.74	S_2	0.754005	-0.01	-1.77
2011	0.66	S_1	0.751036	-0.09	-11.86

Table 2: Analysis of predicted values between GM(1,1) model and grey Markov model with actual values.

Year	Actual value	GM(1,1)model prediction value	GM(1,1)model prediction accuracy (%)	The prediction value of GM prediction model	Accuracy (%)
2008	0.85	0.759979	89.66	0.8349	98.50
2009	0.83	0.756986	90.76	0.8162	97.86
2010	0.74	0.754005	98.23	0.7306	98.65
2011	0.66	0.751036	88.14	0.6789	97.50

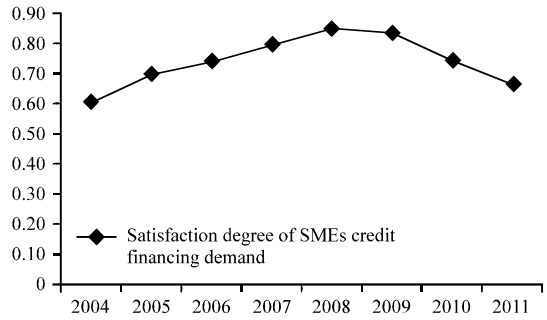

Fig. 2: Satisfaction degree of SMEs credit financing demand

SMEs credit financing demands, the result is a = 0.003946, b = 0.772914. GM(1,1) Prediction model is:

$$x(k+1) = -195.28e^{(-0.0039k)} + 195.88 \quad (11)$$

It can be calculated that the prediction value of satisfaction of SMEs credit financing demands as Table 1.

Status division and transition: According to the characteristics of SMEs and the impact of access to finance on enterprises' development, the structure of SME financing was analyzed. Expert opinion method was adopted to determine the status distribution range of satisfaction degree of SMEs credit financing demands. With ten experts' estimation, that four for the enterprise, three for the banking financial institutions, two for government department, one for banking supervision department, Arithmetic average method was used to code with the data. Then three status value were obtained which one is fully satisfy status S_1 = (0,0.62),one is satisfy status S_2 = (0.62,0.79),one is unsatisfied status S_3 = (0.79,+8).

Base on the above status division, the status transfer situation between 2007 and 2009 was gained (Table 1). The relevant status transfer matrix is:

$$p(1) = \begin{bmatrix} 0 & 1 & 0 \\ \frac{1}{3} & \frac{1}{3} & \frac{1}{3} \\ 0 & \frac{1}{3} & \frac{2}{3} \end{bmatrix}$$

Analysis of the predicted value: According to the status transfer probability matrix calculated above and combining with the grey Markov model, satisfaction degree of SMEs credit financing demands between 2008 and 2011 can be predicted. The effectiveness of two prediction models could be inspected by comparing the predicted values which are from GM(1,1) model and grey Markov model with the actual values from Table 2. From the table, there are less errors by using gray Markov prediction model and the predict accuracy of result is generally higher than GM(1,1) model's .The gray Markov prediction model has more useful application value. The comparison is as follows.

CONCLUSION

Grey Markov prediction model has the advantage of gray prediction and Markov model and can take full advantage of the information given by demand. Introducing SMEs' demand satisfaction degree, the level of SMEs' demand satisfaction could be effectively reflected. The gray Markov prediction model has both the advantages of gray prediction and Markov model, So information included with the historical fund demand data

can be fully used to predict. The satisfied extension of demand for SMEs' credit financing could effectively reflect importing credit financing demand and satisfy utilizing the gray model forecasting curve to reflect the general development trend of the satisfy extent of demands for SMEs' credit financing and putting the prediction curve as a benchmark. Then use the Markov prediction model to search the transfer status of demand satisfaction for SMEs' credit financing. The analysis results show that using the grey Markov model to predict the demand satisfaction for SMEs' credit financing that the random fluctuation is larger and will have higher precision and accuracy. It is approaching to the actual value and can provide decision basis on arranging credit funds scientifically for banks.

ACKNOWLEDGMENTS

The research is supported by the National Social Science Fund of China (Grant No. 10BGL010).

REFERENCES

Akterujjaman, S.M., 2010. Problems and prospects of SMEs loan management: A study on Mercantile Bank Limited, Khulna Branch. J. Bus. Technol. (Dhaka), 5: 38-52.

Angelini, P., R. Di Salvo and G. Ferri, 1998. Availability and cost of credit for small businesses: Customer relationships and credit cooperatives. J. Banking Finance, 22: 925-954.

Atherton, A., 2012. Cases of start-up financing: An analysis of new venture capitalisation structures and patterns. Int. J. Entrepreneurial Behav. Res., 18: 28-47.

Chen, Y.B., J.G. Che and Z.B. Yang, 2009. The demand forecast of equipment maintenance material based on the exponential smoothing method. Command Control Simul., 31: 115-117.

Liu, H.S. and B.Y. Li, 2003. Coordinating mechanism of SMEs? loan financing interest under government incentive. Syst. Eng., 12: 45-50.

Liu, K., 2004. Practical Markov Decision Process. Tsinghua University Press, Beijing, China.

Liu, S.F. and N.M. Xie, 2008. The Grey System Theory and Application. Science Press, Beijing, China.

Osei-Assibey, E., G.A. Bokpin and D.K. Twerefou, 2012. Microenterprise financing preference: Testing POH within the context of Ghana?s rural financial market. J. Econ. Stud., 39: 84-105.

Zhang, Q., 2010. Grey forecasting and the empirical analysis of logistics demand. J. Harbin Inst. Technol., 12: 84-89.