# Comprehensive Evaluation Model of Cross-border E-commerce Credit Risk

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**Abstract**

*In order to obtain the ideal cross-border electrician credit risk assessment results, this paper proposes a gray correlation analysis and least squares support vector machine for cross-border e-commerce credit risk assessment model for cross-border e-commerce credit risk assessment The First of all, according to the relevant research to build cross-border e-commerce credit risk assessment indicators, and the use of gray relational analysis of the evaluation results selected the most important evaluation indicators; and then use the least squares support vector machine cross-border e-commerce credit risk assessment samples to learn, and constructs the evaluation model of cross-border e-commerce credit risk. Finally, the validity and superiority of the model are analyzed. The results show that the model can improve the accuracy of cross - border e-commerce credit risk and provide valuable reference information for cross - border electricity trading.*

**Key words:** cross-border e-commerce; credit risk; risk assessment

## 1 Introduction

Since the development of cross-border e-commerce, it has undergone three phases: forming, developing and maturing. Prior to 2012, it focused on human purchasing, then some B2C cross-border e-commerce platforms emerged from 2012 to 2015. Since 2016, new consumption upgrades have been completed and the tax exemption has been abolished. Cross-border e-commerce has developed rapidly these years in China. According to the information obtained from AIIM, we can see that the overall transaction volume of cross-border e-commerce in China reached 6.3 trillion in 2016, and it is estimated that it will reach 8.8 trillion in 2018, the number of users will reach 74 million [1]. This will be another progress for cross-border e-commerce. However, this also means that the competition among cross-border e-commerce operators is even more fierce, as the popularization of the cross-border consumer, they will pay more attention to the quality and categories of goods, safety, cross-border e-commerce logistics services, returns and other issues, which leads to more trading risks in the development of cross-border e-commerce. For the major cross-border e-commerce enterprises, the premise of meeting the different needs of cross-border consumers is to evaluate various possible transaction risks, evade them in advance or solve them effectively, so as to seize more users in the mature period of cross-border e-commerce. Therefore, it is very important to evaluate the transaction risk existing in cross-border e-commerce and make a more suitable credit risk management system.

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Theoretically, the research on credit risk, especially which of cross-border e-commerce, is involved with many aspects. At present, the research on assessment of cross-border e-commerce credit risk is still not perfect, and the evaluation models of cross-border e-commerce credit risk are also rare at home and abroad, which are mainly focused on e-commerce credit risk assessment. From the perspective of the business model of e-commerce, because of the booming trend of B2C market and the rapid growth of C2C market in recent years, the credit risk assessment studies mainly focused on the B2C and C2C model. The research on B2C model credit is very rich, including the definition of trust[2][3], the dimension of trust[4][5], the influence of trust[6][7], the model of trust[8] and so on. As for the C2C model, the more typical trust models include Abdul-Rahman[9], Mui[10], Yu[11], J. Sang[12] and Sporas[13]. From the perspective of research methods, it includes qualitative and quantitative aspects, including rough sets, fuzzy theory, expert evaluation, failure tree evaluation, event tree evaluation, trustworthy risk assessment[14][15] and so on. Credit risk assessment of cross-border e-commerce is relatively small, and most of them are in recent years. Through analyzing and summarizing the development status of global cross-border e-commerce and Chinese cross-border e-commerce, Ni Cheng et al.[16] classified the cross-border e-commerce credit risk into five parts: commodities, false advertisements, payment methods, third party logistics and supervision system, then they put forward suggestions for enterprises and governments respectively. Zhang Youtang et al[17] studied the self-management risks of cross-border e-commerce credit risk and analyzed its formation mechanism. They designed the "three-dimensional" risk warning index system according to the risks inherent in the business flow, logistics and capital flow , then they built an early warning index location model. Ye Yueqing[18] selected cross-border e-commerce credit rating indicators based on rational behavior, transaction costs, game theory, credit risk management, signal theory and other economic theory, and built a credit evaluation model of cross-border e-commerce using fuzzy comprehensive evaluation method. Shan Dandan[19] constructed a trade credit game model of cross-border e-commerce and simulated it with Agent-Swarm.

Through the above review of the literature on e-commerce transaction risk and cross-border e-commerce credit risk assessment, we can see that there are some subjectivity and blindness in general qualitative research, and the accuracy of the assessment results is not good. However, the reality is that most of the cross-border e-commerce transactions have no relevant prior knowledge, which will further increase the difficulty of qualitative analysis and the uncertainty of the results. As a result the accuracy of cross-border e-commerce transaction evaluation is low and the assessment results are less credible. Quantitative analysis is a cross-border e-commerce credit risk assessment technique based on modern statistical theory, its assessment accuracy is better than qualitative analysis, and the interpretation of the evaluation results is also better. Cross-border e-commerce credit risk assessment based on quantitative analysis can improve the efficiency of cross-border e-commerce credit risk assessment. Least square support vector machine (LSSVM) solves the problem that support vector machine learns slowly and neural network are always over-fitting, provides a new tool for cross-border e-commerce credit risk evaluation[20]. In order to obtain a better credit risk assessment result of cross-border e-commerce, we proposed a cross-border e-commerce credit risk evaluation model (GRA**-**LSSVM) based on gray relational analysis (GRA) and LSSVM. The results show that GRA**-**LSSVM can obtain high-precision cross-border e-commerce credit risk assessment results.

## 2 Construction of Cross - border E - commerce Credit Risk Index System

### (1) Credit Risk Analysis

Cross-border e-commerce transaction is a process in which cross-border e-commerce businesses sale products and services to individual consumers online through various types of online platforms, and then individual consumers pay through third-party payment platform. Therefore, the credit risk of cross-border transactions involves not only the credit problems of cross-border e-commerce enterprises themselves, but also the security issues of cross-border payment and the fraud or disclosure of transaction information during the transaction.

In assessing the credit of cross-border e-commerce enterprises, firstly, we need to consider the state of cross-border operation of the enterprises and evaluate them from four aspects: enterprise quality, management ability, development potential and cross-border service capability. Secondly, we should attach importance to the financial status of enterprises, in the establishment of evaluation index system, we should not only consider the profit target, but also consider the cash flow indicators and the ability to repay the debt. Finally, the current system of credit construction in our country is still not perfect. There are some problems such as the imperfect credit laws and the lack of integrity database. The credit supervision mechanism has not been formed yet, which leads to the weak credit awareness and malicious evasion of cross-border enterprises. Therefore, we must also pay attention to the past creditworthiness of cross-border enterprises.

At present, in the field of cross-border e-commerce, multiple payment methods such as credit card, bank transfer, third-party payment exist at the same time. Traditional foreign trade payment process is mature and has a good dispute resolution mechanism, but cross-border e-commerce payment is in its infancy. In the face of higher payment risk, There are still many problems that need to be solved, such as payment system stability, network security and so on.

There are information fraud and information disclosure and other issues in the process of cross-border e-commerce transactions, affecting the security of online transactions. On the one hand, cross-border e-commerce enterprises often lack the legal knowledge, and at the same time, they often produce and sell fake and shoddy products due to their weak innovation ability and the desire to get more interest. On the other hand, cross-border e-commerce transactions are mostly online transactions, customers can not distinguish the quality of the goods, which will lead to many adverse consequences. In addition, generally speaking, the transaction process generally involves the information of both parties, and a large amount of information is private information such as home address, payment of real name, contact number, ID number and bank card. However, as cross-border e-commerce enterprises pay insufficient attention to information protection, they deliberately or inadvertently disclose the transaction information of the other party. Moreover, third-party payment and distribution can easily lead to customer information disclosure.

(2) Cross-border E-commerce Credit Risk Evaluation Index System

Considering the factors affecting the credit risk of cross-border e-commerce are complex and they affect each other, we need to obey the principles of scientificity, legality, comprehensiveness, pertinence and operability in the construction of cross-border e-commerce evaluation index system. The credit risk will be divided into three categories: cross-border e-commerce enterprises own credit risk, information risk and laws and regulations. Its evaluation index system is shown in Figure 1.

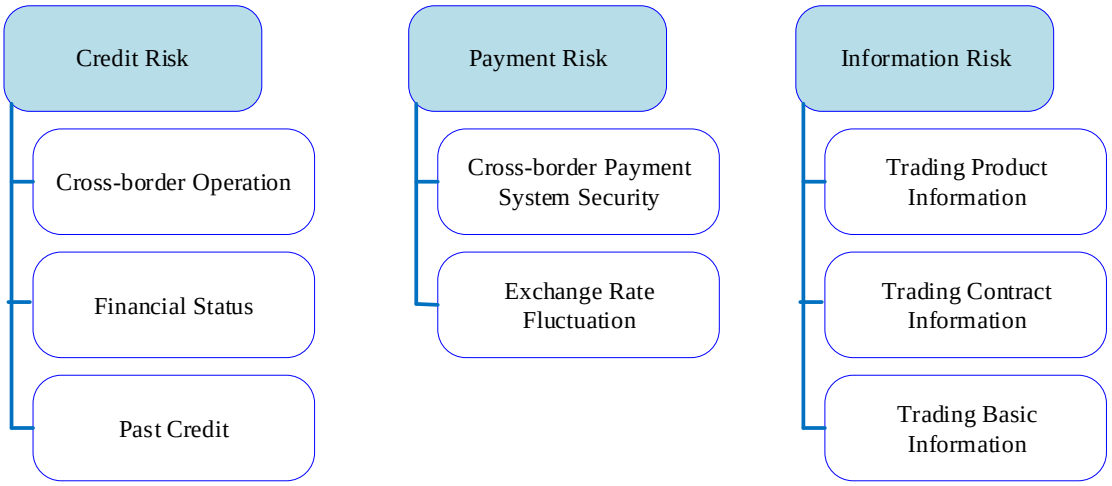


Fig.1 Credit risk analysis

1) Cross-border e-commerce own credit risk A, as shown in Table 1.

Table 1 Cross-border E-commerce Own Credit Risk Evaluation Index System

| Grade I indexes | Grade II indexes | Grade III indexes |
|---|---|---|
| Cross-border operation $A_1$ | Enterprise quality $A_{11}$ | Financial information quality |
| | | Loan compliance |
| | | Trading performance |
| | Management capacity $A_{12}$ | Enterprise size |
| | | Manager quality |
| | | Funding self-sufficiency rate |
| | Development potential $A_{13}$ | New product development capability |
| | | R & D investment intensity |
| | Cross-border service capability $A_{14}$ | Pre-sales / after-sales service |
| | | Cross-border network service marketing |
| Financial Status $A_2$ | Profitability $A_{21}$ | Sales growth rate |
| | | Profit growth rate |
| | Solvency $A_{22}$ | Loan repayment rate |
| | | Interest coverage multiple |
| | | Quick ratio |
| | | Flow ratio |
| | | Cash ratio |
| | Operational capability $A_{23}$ | Total asset turnover rate |
| | | Current asset turnover rate |
| | | Inventory turnover rate |
| | | Accounts receivable turnover rate |
| Past Credit $A_3$ | Bank credit $A_{31}$ | Loan repayment rate |
| | | Loan interest payment rate |
| | Commercial credit $A_{32}$ | The average payment period of accounts payable |
| | | Loan payment rate |
| | Quality inspection credit $A_{33}$ | Cross-border product quality inspection results |
| | | Punishment records |
| | | Quality inspection credit rating |
| | Customs credit $A_{34}$ | Punishment records |
| | | Customs credit rating |
| | Tax credit $A_{35}$ | Tax records |
| | | Tax credit rating |
| | Adverse public record $A_{36}$ | Tax arrears, wages, illegal operations and so on |
| | Manager personal reputation $A_{37}$ | Manager credit evaluation results |

2) Cross-border e-commerce payment risk B, as shown in Table 2

Table 2 Cross-border E-commerce Payment Risk Index System

| | | |
|---|---|---|
| Cross-border Payment System Security $B_1$ | Cross-border transaction network security $B_{11}$ | Cross-border trading platform information certification |
| | | User information disclosure |
| | | User Privacy Policy |
| | Cross-border transaction payment security $B_{12}$ | Payment method |
| | | Cross-border payment service providers |
| | | Cross-border payment technical support |
| | | Payment system stability |
| Exchange Rate Policy$B_2$ | Exchange rate fluctuations $B_{21}$ | |

3) Cross-border e-commerce information risk C, as shown in Table 3

Table 3 cross-border E-commerce risk index system

| | |
|---|---|
| Cross-border product information $C_1$ | Product category $C_{11}$ |
| | Product certification $C_{12}$ |
| Cross-border transaction contract information $C_2$ | Contract amount $C_{21}$ |
| | Contract breach clause $C_{22}$ |
| Cross-border transaction basic information $C_3$ | Cross-border transaction mode $C_{31}$ |
| | Cross-border transaction frequency $C_{32}$ |
| | Cross-border transaction success rate $C_{33}$ |
| | Accumulated cross-border transaction amount $C_{34}$ |
| | Growth rate of new Overseas customers $C_{35}$ |
| | Overseas customers re-purchase rate $C_{36}$ |

## 3 Evaluation Method Selection

According to the above indicators, there are many factors that affect the credit risk of cross-border e-commerce, resulting in a huge index system of credit risk comprehensive evaluation. Therefore, in the actual assessment, in order to improve the accuracy and credibility of the assessment results, it is necessary to screen and analyze the influencing factors involved. As the comprehensive evaluation index system of credit risk is qualitatively selected, if there are too many influencing factors, the uncertainties of the correlation between influencing factors will lead to a large error in the assessment results. However, if the selected factors are too small, it is difficult to fully reflect the degree of the cross-border e-commerce's credit risk. So it is necessary to select the main factors that affect the credit risk of cross-border e-commerce as comprehensively as possible and guarantee the relative independence of the selected factors. Therefore, it is necessary for us to conduct a correlation analysis on the factors that affect the credit risk of cross-border e-commerce. Among them, gray relational analysis is the most commonly used method.

### 3.1 Gray Relational Analysis

Gray system theory is a theoretical method proposed by Chinese scholar Professor Deng Julong in the 1980s. This theory provides a simple, rapid and accurate solution to the problem of less data and poor information[21]. The measure of the correlation between two systems or two factors is called the degree of correlation, which describes the relative change of factors in the process of system development. Gray relational analysis is a quantitative description and comparison of a system development trend.

Step1: define the relationship between various factors of credit risk

Assume that the two-way relationship between different evaluated cross-border businesses is $Y_0$ and $Y_i$, respectively shown as follow:

$$Y_0 = \{y_0(1), y_0(2), \ldots y_0(k), \ldots, y_0(n)\}$$
$$Y_i = \{y_i(1), y_i(2), \ldots y_i(k), \ldots, y_i(n)\} \quad (1)$$

Step2: raw data transformation

Since the dimensions of the various factors in the system are not necessarily same, and the orders of magnitude vary greatly, the data can not be compared directly. Therefore, the original data needs to be converted to eliminate the differences caused by different dimensions. In this paper, we adopted the method of initial value transformation, that is, the first data of the same sequence is used to divide each subsequent original data, and the obtained new multiple data sequence is called an initialized number sequence. Its characteristic is the value of each sequence is greater than 0, and the dimension is one, that is:

$$X_0 = \{x_0(1), x_0(2), \ldots x_0(k), \ldots, x_0(n)$$
$$X_i = \{x_i(1), x_i(2), \ldots x_i(k), \ldots, x_i(n)\} \quad (2)$$

In the formula, $x_0(k) = y_0(k) \Big/ \sum_{i=1}^{n} y_0(t); x_i(k) = y_i(k) \Big/ \sum_{i=1}^{n} y_i(t)$.

Step3: calculate the correlation coefficient

According to the calculation formula of the correlation coefficient, the correlation coefficient between different credit factors of each cross-border business is calculated, that is, the correlation coefficient $x_{0,i}(k)$ with the k point is:

$$x_{0,i}(k) = \frac{\min\limits_i \min\limits_k \left|x_0(k) - x_i(k)\right| + r \max\limits_i \max\limits_k \left|x_0(k) - x_i(k)\right|}{\left|x_0(k) - x_i(k)\right| + r \max\limits_i \max\limits_k \left|x_0(k) - x_i(k)\right|} \quad (3)$$

In the formula, $r$ is the resolution coefficient, $0 \le r \le 1$, generally take $r = 0.5$.

Step4: seek relevance

Gray relational similarity coefficient can only find the association of one factor, can not reflect the relevance of all factors together. So it is also necessary to determine the gray relational degree between different cross-border platforms or cross-border businesses, which indicates the overall correlation between the platforms so that consumers can conduct credit analysis from the whole. That is:

$$r_i = \frac{1}{n} \sum W(k) \xi_{0,i}(k), k = 1, 2 \cdots n \quad (4)$$

Wherein, $W(k)$ represents weight value different correlation coefficients.

The geometric representation of the degree of association is shown in the figure2, where $k$ represents time, $\xi$ represents the correlation coefficient, and the area enclosed by the broken line and the horizontal axis is called the correlation area.

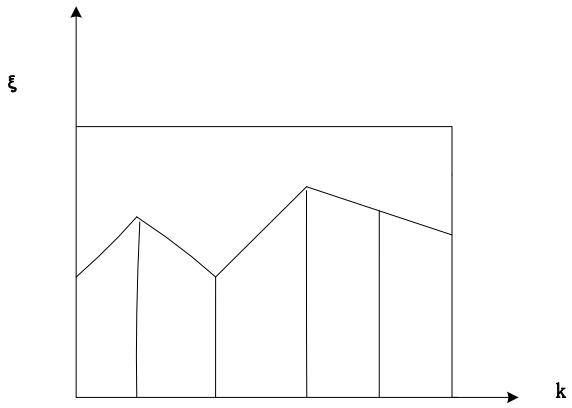


Fig. 2 Geometry of the degree association

### 3.2 Least Square Support Vector Machine

The SVM method is based on the theory of VC dimension of statistical learning theory and the minimum principle of structural risk. Based on the limited sample information, the best compromise between the complexity (learning accuracy for a specific training sample) and learning ability (the ability to identify any sample without errors) of the model is sought to obtain the best promotion ability. However, SVM has some shortcomings such as long time and high complexity in the computation time. So the LSSVM makes a certain improvement on it. If the training sample set is $(x_i, y_i)$, the decision function of LSSVM is:

$$f(x) = w^T j(x) + b \tag{5}$$

Where, $\omega$ and $b$ represent the relevant parameters.

Support Vector Machine (SVM) is based on the principle of minimum structure risk. Based on this, LSSVM can ensure that the complexity of the calculation and classification error can be balanced. We can transform formula (5) into:

$$\begin{aligned} &\min_{\omega,b,e} J(\omega,e) = \frac{1}{2}W^T W + \frac{\gamma}{2}\sum_{i=1}^{n} e_i^2 \\ &s.t.\ \ y_i = \omega^T \varphi(x) + b + e_i, i = 1,2,\cdots l \end{aligned} \tag{6}$$

Among them, $\gamma$ represents the normalization parameter of least square support vector machine, which is the decisive factor of its classification effect.

In the actual solution, the "dual problem" can be obtained by using the Lagrange multiplier method for the formula (6), that is, the Lagrange multiplier $\alpha_i \geq 0$ is added to each constraint of the formula (6) Then the Lagrange function becomes:

$$L(\omega,b,e,\alpha) = J(\omega,e) - \sum_{i=1}^{l} \alpha_i (\omega^T \varphi(x_i) + b + e_i - y_i) \tag{7}$$

The solution process needs to satisfy KKT conditions, so we get:

$$\begin{bmatrix} 0 & e_1^T \\ e_1 & Q + C^{-1} I \end{bmatrix} \begin{bmatrix} b \\ \alpha \end{bmatrix} = \begin{bmatrix} 0 \\ y \end{bmatrix} \tag{8}$$

Wherein, $I$ represents a unit matrix, $Q_{ij} = \left(\varphi(x_i)\varphi(x_j)\right)$, and:

$$\begin{cases} y = (y_1, y_2, \cdots, y_l)^T \\ e_1 = (1,1,\cdots,1)^T \\ \alpha = (\alpha_1, \alpha_2, \cdots, \alpha_l)^T \end{cases} \tag{9}$$

In the next step, we use LSSVM to classify the training samples linearly. However, in practical tasks, there is often no"hyperplane" that can happen to be correctly classified in the training samples. That is, there are two kinds of training samples: the linear one and the non-linear one. For non-linear training samples, the kernel function is used for transformation, here classifying the Gaussian kernel function LSSVM of common kernel function as:

$$f(x)=\operatorname{sgn}\left(\sum_{i=1}^{n} a_i \exp\left(-\frac{\left\|x_i - x_j\right\|^2}{2s^2}\right)+b\right) \tag{10}$$

Where $\sigma$ is the parameter of Gaussian kernel function (RBF).

There are many factors that affect the credit risk of cross-border e-commerce. Therefore, the level of cross-border e-commerce credit risk is also varied. For the traditional LSSVM method, most of them are used to solve the problem of training sample classification. For a variety of classification problems, if the LSSVM method is adopted, it needs to be classified layer by layer to construct a classifier suitable for the multi-level classification problem of cross-border e-commerce credit risk. The specific operations are as follows:

Step1: Enter the data of each risk factor affecting the credit of cross-border e-commerce, set a certain threshold, sort the data for the LSSVM first time and output the data.

Step2: Divide the risk data into general risk data and other data sets S after Step1, output the general risk data directly, set a certain threshold, continue to perform the second LSSVM classification on the other data, and output the data again.

Step3: After Step2, divide other data sets S into serious risk data and other data sets $S_1$, directly output the serious risk data and set a certain threshold, continue the third LSSVM classification for the other data sets $S_1$, and then output again.

Step4: The output data is divided into larger risk data and safety data. At this point, we have obtained four types of data: general risk, serious risk, larger risk and safety, and classified the cross-border e-commerce credit risk successfully.

## 4 Simulation Analysis

### 4.1 Sample Data

To validate the cross-border e-commerce credit risk assessment model based on GRA**-**LSSVM, we choose 200 cross-border e-commerce transaction credit samples, and divide the credit risk of cross-border e-commerce transactions into four levels: general risk, serious risk, large risk and safe, and quantify them, respectively, with 1,2,3,4, values (Table 4), the sample data as shown in Figure 3. In this paper, we select 120 samples as a training set to build the cross-border e-commerce credit risk assessment model based on GRA**-**LSSVM, and other samples were used as testing sets to test and analyze the performance of GRA**-**LSSVM cross-border e-commerce credit risk assessment model. All the experiments were implemented on Matlab R2010b platform.

Table 4 Risk Classification and Presentation

| Factors | The level of risk | | | |
|---|---|---|---|---|
| | General risk | Serious risk | large risk | safe |
| Cross-border e-commerce credit Risk factors | 1 | 2 | 3 | 4 |

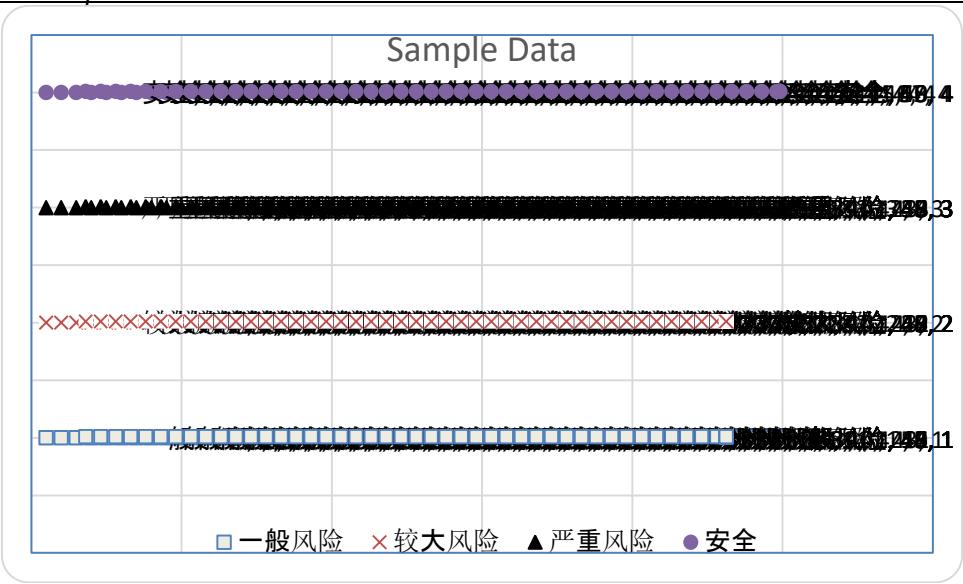


Fig.3 Sample Data

### 4.2 Select the Indicators for Evaluation

In order to determine the contribution rate of each evaluation index to the credit risk assessment of cross-border e-commerce,we select gray relational analysis to process all the evaluation indexes. The contribution rate of each evaluation index is shown in Table 5. According to each evaluation index contribution rate which is the weight of the selected six evaluation indicators as the input vector LSSVM, which are bold in Table 1, and delete some of these not important evaluation indicators.

Table 5 Evaluation indicators contribution rate

| Indexs | $A_{11}$ | $A_{12}$ | $A_{13}$ | $A_{21}$ | $A_{22}$ | $A_{31}$ | $A_{32}$ | $A_{33}$ | $A_{34}$ | $A_{35}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Numbering | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $x_6$ | $x_7$ | $x_8$ | $x_9$ | $x_{10}$ |
| Contribution rate | 0.22 | 0.12 | 0.11 | 0.12 | 0.12 | 0.11 | 0.02 | 0.06 | 0.07 | 0.05 |

### 4.3 Evaluation Results Analysis

The training samples and the test samples are evaluated according to GRA to get the training set and the test set, then establish the evaluation model of GRA-LSSVM. The evaluation results of the test set are shown in Figure 4.

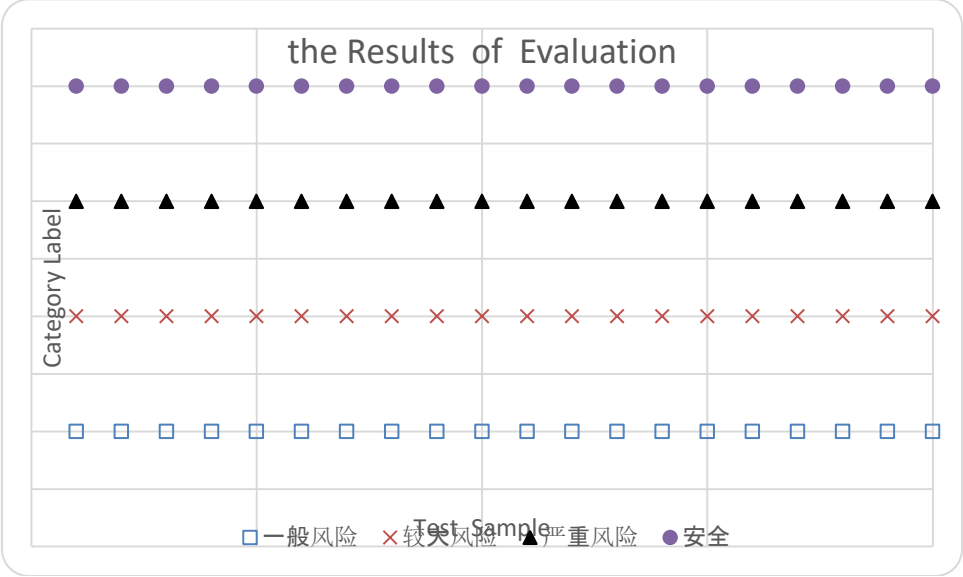


Fig.4 the Results of Evaluation

The GRA-LSSVM's cross-border e-commerce credit risk assessment accuracy is very high. And the assessment results are reasonable, with high reliability.

### 4.4 Superiority Verification

We choose the LSSVM to compare with GRS + SVM model (GRA + SVM), GRA + BPNN (GRA + BPNN) which don't adopt GRA model to evaluate the indicators processing of these model. shown in Table 6.

Table 6 compares the accuracy of evaluation with the classical model

| classical model | accuracy（%） |
|---|---|
| LSSVM | 90.11 |
| GRA-SVM | 85.99 |
| GRA-BPNN | 84.13 |
| GRA-LSSVM | 92.98 |

According to table 6, we can see that the GRA-LSSVM-based cross-border e-commerce credit risk assessment model is more accurate than other models. And it has obvious advantages. The assessment results can provide valuable reference information for cross-border e-commerce transactions. And it can ensure the security of the transaction to a certain extent.

## 5 Conclusion and Outlook

In recent years, with the booming development of cross-border e-commerce in our country, all kinds of cross-border e-commerce platforms have sprung up and competition has become more and more intense. The popularization of cross-border e-commerce has brought more and more consumers for seller. But with the increasing of consumption level and the choice of space, Consumers are also paying more attention to various issues such as product quality, category, safety, cross-border e-commerce logistics services, returns and other various problems. The transaction credit of cross-border e-commerce is affected by many factors, including the internal factors such as the cross-border business conditions of the enterprise, financial status and past credit, as well as various external factors such as the market environment of cross-border e-commerce and government policies. These factors interfere with each other, so that the cross-border e-commerce credit risk assessment presents a very obviously non-linear change characteristics. In order to effectively predict the risk of cross-border e-commerce in the transaction process and reduce the losses of all participants, and clearly understand the characteristics of cross-border e-commerce credit risk and provide some useful references for governments and cross-border departments, we conside the current research status at home and abroad as well as the characteristics of cross-border e-commerce transaction credit, and build cross-border e-commerce credit risk assessment model based on GRA-LSSVM. After analyzing the credit risk factors affecting cross-border e-commerce, and verifying the whole model by simulation, we prove the validity and superiority of GRA-LSSVM cross-border e-commerce credit risk assessment model. It can describe all kinds of factors of credit risk, and can reduce the mutual interference between various factors to a certain extent. The GRA method can provide pre-data for the LSSVM classifier to make the selection of indicators easier, eliminate redundancy and reduce the computational difficulty. At the same time, the accuracy of cross-border e-commerce credit risk assessment has also been raised to a certain extent, which has certain value both in theory and application.

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