The application of Euclid approach degree comprehensive evaluation method in credit evaluation of commercial circulation enterprises

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Abstract. Based on the thorough analysis of the factors affecting the credit level of commercial circulation enterprises, a scientific and systematic evaluation index system was established. By adopting the fuzzy matter-element analytical method, which especially suits the multi-index and incompatibility issue, the evaluation model was built. The comprehensive integrated weighting method was applied for the determination of the index weight. Meanwhile, the subjective and objective information were considered comprehensively to elaborate the inherent law of the commercial circulation enterprise credit risk evaluation, which provide a practical and effective method for judging the credit level of commercial circulation enterprises and analyzing the key influencing factors of credit evaluation, and also provide a direction and reference for improving the credit level of commercial circulation enterprises.

1. Introduction

At present, the construction of social credit system has become an important means of improving market economy system and pushing forward the modernization of society governance capability. Credit level has become an important index that evaluates the status of market economy. The lack of credit may cause serious consequences and hinder the healthy and sustainable development of economy. Serious credit loss causes decline of social morality and the serious loss of consumers’ consumption confidence; what’s worse, it adds to transaction cost in the process of market transaction. The increase of transaction cost incurs more people’s dishonest behaviors to make up for their loss. This is a vicious circle and enormous economic loss can be caused eventually [1].

Commercial circulation enterprises work on commodity circulation and supply services for commodity circulation. Involving wide scope of enterprises, retail and wholesale industry, catering industry, storage industry, transport industry etc. are included. Commercial circulation and commodity market is important intermediate link that links production and consumption. It reflects the maturity degree of market economy. The credit level of commercial circulation enterprises directly influences the development of the whole economy. At present, lack of credibility in commercial circulation industry often happens, which has a strong impact on the healthy and orderly development of commercial circulation market. Therefore, objective and reasonable analysis and evaluation on the credit level of commercial circulation enterprises and the construction of commercial circulation enterprises’ credit system are important measures for competent department of commerce to accelerate function transformation, strengthen public services and deepen system reform. Commercial circulation enterprises’ credit evaluation index system can be a scientific guide to the construction of the credit system in commercial circulation industry. It has important practical significance for raising the credit
level in commercial circulation industry, reasonable allocation of commercial circulation enterprises’ credit resources, building commercial circulation market environment of honesty and trustworthiness and promoting the sustainable development of commercial circulation industry.

Matter-element analysis is a new discipline established in 1994 by Chinese scholar CAI wen [2], which is dedicated to solving incompatible problems. Fuzzy matter-element combines fuzzy set theory [3] and matter-element analysis theory, which can not only solve the fuzziness of evaluation factors, but also solve the incompatibility of evaluation results. Due to its characteristics of simple calculation method, reliable evaluation result and strong practicability, this theory has been widely applied in the fields of water environment protection [4-5], logistics technology [6], electromechanical [7-8], construction [9] and so on. In the aspect of enterprise credit evaluation, the multi-factor comprehensive evaluation method is widely used. In recent years, principal component analysis, fuzzy analytic hierarchy process, econometric model, artificial neural network model, cloud model, hierarchical linear model and other methods have also been applied to evaluation. Domestic scholars mostly adopts AHP and fuzzy comprehensive evaluation methods such as analytic hierarchy process, and some scholars Logistic model is used to establish a credit risk evaluation model, using Logistic model to analysis the financial credit risk problem has good practicability, but there are defects, when the variable is too much, can lead to multicollinearity and irrelevant variable disturbance. Lu yuduo [10] introduced the lasso-logistic model into the supplier financial credit evaluation. Due to the large difference in some attributes among different competitors, the model constructed by Lu yuduo to evaluate the supplier financial credit risk is only applicable to the automobile industry. When evaluating different industries, the corresponding evaluation model should be adjusted according to the industry characteristics. Taking big data as the research background, Zhang yongchun [11] chose the grey comprehensive evaluation method to evaluate credit risk, and determined the credit risk level through the degree of correlation. Liu lei [12] used factor analysis to evaluate the partner credit under the background of dynamic alliance of construction projects. Zhang hongxiang [13] conducted grey fuzzy credit evaluation on the evaluated samples from the perspective of multidimensional time series, and solved the distortion caused by data mutation. Ding juanjuan et al. [14] gave a fuzzy evaluation method of enterprise talents’ occupational credit rating, which solved the problem of talent's occupational credit rating evaluation well. Based on the characteristics of the construction market, Fan zhiqing et al. [15] proposed an evaluation index system to measure the credit of qualified practitioners and made an empirical analysis by using matter-element analysis method.

So many complex evaluation methods are not necessarily applicable to commercial circulation enterprises credit evaluation, has the difficulty in one way or the other, such as: (1) the common evaluation methods are usually according to the score value artificially divided enterprise credit rating standard interval, then according to the credit rating standard interval to determine the research object of credit rating, subjectivity is stronger;(2) the common evaluation method is usually to use the evaluation model to synthesize the scattered information, and then use the comprehensive score value to grade the level of the research object, which is easy to ignore the implicit information between the evaluation indicators;(3) most evaluation methods can only evaluate the credit risk level of the research object, but cannot indicate whether the research object is stable at this level or whether it is in a state of transformation to other risk levels. Circulation enterprise credit assessment is relative to the general enterprise credit evaluation, because involves the industry characteristics of the variety and field widely, itself has a certain ambiguity, causes of broken subjective factors and objective factors, and there are multiple aspects of incompatible evaluation index, choose the fuzzy matter-element analysis circulation enterprise credit evaluation model is set up, using the fuzzy mathematical description for fuzzy characteristic of evaluation objects, fully embodies the circulation process characteristics of the enterprise credit evaluation. Therefore, in view of the shortcomings of previous evaluation methods, this paper tries to apply the fuzzy matter-element analysis method to the credit evaluation of commercial circulation enterprises, in order to find a more suitable credit evaluation method for commercial circulation enterprises. The main advantages of this method are as follows: it can deal with both quantitative and qualitative indicators; reflect the process of credit evaluation, and update the evaluation
index at any time according to the changes of the actual situation, so as to adapt to the requirements of dynamic changes; can give intuitive evaluation results.

2. Credit evaluation indexes for commercial circulation enterprises

Many factors influence the credit of commercial circulation enterprises. Credit evaluation model is needed for scientific analysis on the credit level of commercial circulation enterprises and finding the key factors which influence the credit of commercial circulation enterprises. National standard GB/T 23794-2015 Index of Enterprise Credit Evaluation lists basic elements which influence enterprises’ credit level, including values, contractual capacity and social responsibility [16]. Values is the value orientation of enterprises’ decision makers, the basic belief and target pursued in enterprises’ business process; contractual capacity is enterprises’ synthetic ability for fulfilling promise and achieving their value; social responsibility of enterprises is to take responsibilities of interested parties and fulfill promises. It can be seen that contractual desire, contractual capacity and contractual performance are the main factors which influence the credit level of enterprises. A basic model of enterprise credit evaluation is built on basis of the three factors. Enterprises’ contractual desire is the essential factor that determines enterprises’ contractual performance and result. Enterprises’ contractual capacity is the basic influence factor. Contractual capacity determines the degree of fulfilling contractual performance and result. Enterprises’ contractual performance is the final influence factor. Contractual performance is the behavior of fulfilling promise and the rule of judging whether promise can be fulfilled [17].

| Table 1. Credit evaluation index system for commercial circulation enterprises. |
| --- |
| Target layer | Factor layer | Index layer |
| The credit level of commercial circulation enterprises | Enterprises’ contractual desire | Enterprises’ basic registered information C₁ (including contact information, registered information, altered registered information etc.), associated relation information C₂ (including the information of subsidiary corporations and affiliated agencies) |
| The credit level of commercial circulation enterprises | Enterprises’ contractual capacity | Management information C₃ (including the information of human resource management, business management, intangible asset management etc.), trade information C₄ (including the information of traded products, sale etc.), financial information C₅ (including quality of asset, operation efficiency, growth, profitability, debt paying ability etc.) |
| The credit level of commercial circulation enterprises | Enterprises’ contractual performance | Public credit information C₆ (including judicial records, administrative penalty, financial credit, honor information, complaint information etc.), market credit information C₇ (including self-promise, association evaluation, other evaluation information etc.) |

In the evaluation model, object of evaluation is enterprises’ credit. Therefore, the primary credit factor is the desire of keeping credit, involving the qualification conditions of enterprises, the administrative licensing required for enterprises and products, the requirements of laws and regulations, compulsive management requirements etc. It is the most fundamental requirement to meet the conditions and requirements. In addition, corresponding contractual capacity of enterprises is required such as enterprises’ quality management system, scientific and technological level, financial management, safety management etc. This determines whether enterprises have the ability to manufacture the products which meet customers’ requirements. The final is enterprises’ actual
contractual performance, such as the honors, social responsibilities, administrative penalty etc. which can directly reflect credit of the enterprises. These information can be collected by multiple channels, such as law enforcement, supervision, casual inspection, credit record etc.

To make evaluation index system really reveal the connotation of commercial circulation enterprises’ credit level and accurately reflect the essential features and running laws of commercial circulation enterprises, the characters of commercial circulation industry, existing credit loss risk points and the credit characters of commercial circulation enterprises shall be analyzed while considering the basic indexes which influence the credit level of commercial circulation enterprises. It is required to consider evaluation indexes overall and clearly know their mutual relations and hierarchical structure. Therefore, the credit index system for commercial circulation enterprises shall be built considering the 3 key factors (contractual desire, contractual capability and contractual performance) which influence the credit level of commercial circulation enterprises. In three categories of the factors, referring to the purpose, scientificity, systematicness, operability, comparability etc. of building index system, typical indexes reflecting the 3 key factors are chosen to build a scientific, systematic and all-purpose credit level evaluation index system for commercial circulation enterprises. The system contains 3 layers (target layer, factor layer and index layer), 3 categories and 7 indexes, as shown in Table 1.

The credit level of commercial circulation enterprises is a fuzzy concept influenced by multiple factors. The evaluation index system is a diversified complex system, involving quantitative indexes and qualitative indexes with different change laws. Qualitative indexes are fuzzy and cannot be signified by an accurate value simply, which adds to uncertainty and fuzziness to evaluation result. Besides, there is contradiction among the indexes. The evaluation result of single index tends to be incompatible to each other [18]. Therefore, the evaluation on the credit level of commercial circulation enterprises shall start from its fuzziness and incompatibility of evaluation result. Matter element analysis theory studies matter element and its change laws. As an effective method that solves the problem of incompatibility, it is especially applicable to multiple qualitative and quantitative indexes evaluation [19].

3. Fuzzy matter element model

3.1. Compound fuzzy matter element matrix

Matter element is a ternary array $R = (M, C, x)$ that is comprised of given scheme or matter M, selected index C (feature vector) and index value x (feature value). If the feature value x is uncertain and fuzzy, R will be fuzzy matter element [20]. m schemes or matters and corresponding n indexes combine to form a compound fuzzy matter element matrix $R_{nm}$. It is given below:

$$R_{nm} = \begin{bmatrix}
M_1 & M_2 & \cdots & M_m \\
c_1 x_{11} & x_{12} & \cdots & x_{1m} \\
c_2 x_{21} & x_{22} & \cdots & x_{2m} \\
\vdots & \vdots & \ddots & \vdots \\
c_n x_{n1} & x_{n2} & \cdots & x_{nm}
\end{bmatrix} \quad (1)$$

3.2. Fuzzy matter element matrix of optimized membership

Optimized membership of evaluation index $x_{ij}$ in schemes or matters is calculated. The matrix comprised of optimized membership is called fuzzy matter element matrix of optimized membership $R_{am}$. It is given below:
\[
\begin{bmatrix}
M_1 & M_2 & \cdots & M_m \\
\mu_{11} & \mu_{12} & \cdots & \mu_{1m} \\
\vdots & \vdots & \ddots & \vdots \\
\mu_{n1} & \mu_{n2} & \cdots & \mu_{nm}
\end{bmatrix}
\]

(2)

In the matrix, \( \mu_{ij} = \frac{x_{ij}}{\max x_{ij}} \) is profitability index; \( \mu_{ij} = \frac{\min x_{ij}}{x_{ij}} \) is cost index.

3.3. Difference-square fuzzy matter element matrix

In ideal status, the index \( \mu_{ij} = 1 \). \( S_{ij} = (\mu_{ij} - 1)^2 \) forms difference-square fuzzy matter element matrix. It is given below:

\[
\begin{bmatrix}
M_1 & M_2 & \cdots & M_m \\
S_{11} & S_{12} & \cdots & S_{1m} \\
\vdots & \vdots & \ddots & \vdots \\
S_{n1} & S_{n2} & \cdots & S_{nm}
\end{bmatrix}
\]

(3)

3.4. Calculation of index weight

3.4.1. Qualitative weight coefficient calculated by expert investigation method. Expert investigation method is simple and visual and can be realized easily. The detailed procedures are given below:

Experts are employed to fill in investigation sheet. Each expert shall be investigated independently. Mutual discussion and opinion exchange is avoided [21]. \( a_{ij} \) is required to meet the condition

\[
\sum_{i=1}^{n} a_{ij} = 1 \quad a_{ij} \text{ means the weight of the } i \text{th index of evaluation object given by the } j \text{th expert.}
\]

Collect all expert investigation sheets. Collect the evaluation index weight coefficients \( a_{ij} \) from all expert investigation sheets.

Calculate the weight coefficient of index \( \alpha_{ij} \).

\[
\alpha_{ij} = \frac{\sum_{i=1}^{n} a_{ij}}{\sum_{j=1}^{m} \left( \sum_{j=1}^{n} a_{ij} \right) }, \quad i = 1, 2, \cdots, n
\]

(4)

3.4.2. Quantitative weight coefficient calculated by entropy weight method. Entropy weight method is objective weighting method. It is calculated depending on objective information of data without the subjective judgment and interference of experts and valuators. The calculation steps are given below:

Build matter element matrix \( R_{nm} \).

Normalize the matter element matrix.
In which: $x_{\text{max}}$ and $x_{\text{min}}$ are the optimal evaluation object and worst evaluation object at the same index, respectively.

Calculate the entropy of evaluation index

$$H_i = -\frac{1}{\ln m} \left( \sum_{j=1}^{m} f_{ij} \ln f_{ij} \right), \quad i = 1,2,\ldots,n, \quad j = 1,2,\ldots,m$$

(6)

In which: $f_{ij} = b_{ij} / \sum_{j=1}^{n} b_{ij}$

Calculate the entropy weight $\beta_i$ of evaluation index

$$\beta_i = \frac{1 - H_i}{n - \sum_{i=1}^{n} H_i}, \quad \sum_{i=1}^{n} \beta_i = 1$$

(7)

3.5. Method of weight coefficient combination

To make the combined weight contain both objective weights and subjective weights and evaluation result close to the actual value, integrated weighting method is used to calculate index weight. This method combines entropy weight method and expert investigation method to combine the objective weights and subjective weights. In this way, information of every index is retained; besides, the knowledge and experience of experts can be used to rectify objective weights.

It is assumed that $\alpha_i$ is the subjective weight of the $i$th index and $\beta_i$ is the entropy weight of the $i$th index got from entropy weight method. The integrated weight of the $i$th index is:

$$\omega_i = \mu \alpha_i + (1-\mu) \beta_i, \quad i = 1,2,\ldots,n$$

(8)

In which: $\mu$ is the preference coefficient of subjective weight and objective weight, $\mu \in [0,1]$.

The integrated weight changes following the change of $\mu$. When $\mu = 1$ and $\mu = 0$, it corresponds with expert investigation method and entropy weight method respectively. As for the reasonable value of $\mu$, the method in literature [22] can be for reference. The preference coefficient of subjective weight is small in this paper: $\mu = 0.4$.

3.6. Comprehensive evaluation based on Euclid approach degree

Approach degree means the degree of approach between evaluation object and standard object. The higher the approach degree is, the smaller the gap between them will be. Conversely, it will indicate large gap between them [23]. In ideal case, index $\mu_{ij} = 1$. The approach degree of standard object is 1. As for commercial circulation enterprises, when credit approach degree is close to standard object approach degree 1, it will indicate high credit level of the commercial circulation enterprise. According to fuzzy matter element of difference square and entropy weight of evaluation indexes, approach degree is:

$$R_p = \begin{bmatrix} M_1 & M_2 & \cdots & M_m \\ D_1 & D_2 & \cdots & D_m \end{bmatrix}$$

$$D_j = 1 - \sqrt{\sum_{i=1}^{n} \omega_i S_{ij}}, \quad j = 1,2,\ldots,m$$

(9)

(10)
4. Application of model

Scientific, comprehensive and reasonable evaluation indexes will directly contribute to the integrated evaluation result. In case of too many indexes, there will be repetitive indexes and the weight of the indexes will be enlarged; the complexity of integrated evaluation calculation and errors of data collection will be expanded. In case of too small number of indexes, they cannot sufficiently represent all and this will not be comprehensive [24]. Evaluation indexes shall be chosen in principles of clear target and comprehensive, practical and feasible method.

Euclid approach degree indicates the degree of approach between evaluated sample and standard sample. The larger it is, the higher the degree of approach between them will be. Conversely, it will be lower. Therefore, Euclid approach degree can be used to judge and analyze credit level of enterprises. The credit evaluation indexes of commercial circulation enterprises can be chosen objectively. The steps of model evaluation can be defined according to the above theory, evaluation system and index evaluation standard: define compound fuzzy matter element, define optimized membership, define fuzzy matter element in standard scheme, define compound fuzzy matter element of difference square and calculate Euclid approach degree of different methods.

The classical domain is the matter-element matrix composed of the feature of things and their standard value range, that is, the classical domain matrix composed of the value of the quantity domain of an evaluation index of a certain evaluation level. It select province involving the drug circulation, catering, beauty salon, second-hand car trading, auction, such as 7 commerce circulating industry companies, according to the region and industry in recent 3 years enterprise credit evaluation index and average, etc., will constitute the five each target level of evaluation: excellent (I level), good (II level), general (III level), poor (IV level) and very poor (V level). Combination of each level standard index respectively gives classification standard, value range \((-\infty, \infty)\), the classification standard of the matter-element, 7 indicators for matter-element characteristic, namely the grading standard and the actual benefit value is the feature about the value of things, but starting from the actual situation, the more the quantity value is, the better the economic benefit of the corresponding index is. The matter-element, features and value of classical field is shown in Table 2.

| Index | Excellent (I level) | Good (II level) | General (III level) | Poor (IV level) | Very poor (V level) |
|-------|-------------------|----------------|--------------------|----------------|-------------------|
| \(c_1\) | \(\geq 3\) | 3~2.5 | 2.5~2 | 2~1 | \(<1\) |
| \(c_2\) | \(\geq 2\) | 2~1.8 | 1.8~1.2 | 1.2~0.5 | \(<0.5\) |
| \(c_3\) | \(\geq 10\) | 10~8 | 8~6 | 6~3 | \(<3\) |
| \(c_4\) | \(\geq 2\) | 2~1.8 | 1.8~1.2 | 1.2~0.5 | \(<0.5\) |
| \(c_5\) | \(\geq 5\) | 5~4 | 4~3 | 3~1 | \(<1\) |
| \(c_6\) | \(\leq 2\) | 2~3 | 3~4 | 4~5 | \(>5\) |
| \(c_7\) | \(\geq 3\) | 3~2.5 | 2.5~2 | 2~1.5 | \(<1.5\) |

Based on the above evaluation model is established in this method, first set up the classical matter-element evaluation grades (standard matter-element) model, combining with the Excel software, calculate the distance between seven enterprises (the actual parameter values) and the interval (classical domain), build the actual matter-element model, and carried out in accordance with the type (5) the normalized processing, form seven circulation enterprise credit evaluation index value distribution is shown in Table 3.
Table 3. Commercial circulation enterprise credit evaluation index value.

| Index | Enterprise 1 | Enterprise 2 | Enterprise 3 | Enterprise 4 | Enterprise 5 | Enterprise 6 | Enterprise 7 |
|-------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| $c_1$ | 2.34         | 2.25         | 2.32         | 2.34         | 2.46         | 2.33         | 2.47         |
| $c_2$ | 1.10         | 1.15         | 1.19         | 1.19         | 1.29         | 1.13         | 1.30         |
| $c_3$ | 8.02         | 8.22         | 8.26         | 8.30         | 8.31         | 8.32         | 8.84         |
| $c_4$ | 1.25         | 1.21         | 1.21         | 1.21         | 1.41         | 1.38         | 1.63         |
| $c_5$ | 3.79         | 3.99         | 4.09         | 4.20         | 4.34         | 4.07         | 4.24         |
| $c_6$ | 2.95         | 2.21         | 2.34         | 1.46         | 1.66         | 1.30         | 1.52         |
| $c_7$ | 1.78         | 1.84         | 1.93         | 2.56         | 2.45         | 2.35         | 2.71         |

For calculation of subjective weights, 6 experts are employed to score credit indexes of commercial circulation enterprises, as shown in Table 4:

Table 4. Data of expert investigation.

| Expert | $c_1$ | $c_2$ | $c_3$ | $c_4$ | $c_5$ | $c_6$ | $c_7$ |
|--------|-------|-------|-------|-------|-------|-------|-------|
| 1      | 0.40  | 0.15  | 0.05  | 0.15  | 0.05  | 0.10  | 0.10  |
| 2      | 0.30  | 0.05  | 0.10  | 0.20  | 0.15  | 0.10  | 0.10  |
| 3      | 0.35  | 0.15  | 0.05  | 0.10  | 0.20  | 0.08  | 0.07  |
| 4      | 0.30  | 0.15  | 0.10  | 0.15  | 0.15  | 0.10  | 0.05  |
| 5      | 0.40  | 0.15  | 0.05  | 0.10  | 0.10  | 0.12  | 0.08  |
| 6      | 0.35  | 0.10  | 0.05  | 0.15  | 0.15  | 0.15  | 0.05  |

Objective and subjective weights are calculated respectively following evaluation steps. Formula (8) is used to integrate weights and the integrated weights are listed in Table 5. In analysis on data, the higher dispersion degree of evaluation indexes in entropy weight method is, the larger weight will be. In comparison among subjective weights, objective weights and integrated weights, integrated weights are between subjective weights and objective weights. In the process of sequencing, the exerts’ will is accepted and objective values are reflected.

Table 5. Integrated weights.

| Weight                  | $c_1$ | $c_2$ | $c_3$ | $c_4$ | $c_5$ | $c_6$ | $c_7$ |
|-------------------------|-------|-------|-------|-------|-------|-------|-------|
| Expert investigation    | 0.35  | 0.125 | 0.0667| 0.1417| 0.1333| 0.1083| 0.075 |
| method                  |       |       |       |       |       |       |       |
| Entropy weight method   | 0.3423| 0.1233| 0.0758| 0.1745| 0.1077| 0.1028| 0.0736|
| Integrated weight       | 0.3454| 0.1240| 0.0721| 0.1614| 0.1180| 0.1050| 0.0742|

The credit level approach degree of commercial circulation enterprises is calculated according to formula (9) and the credit of commercial circulation enterprises is sequenced, as shown in Table 6. In Table 5: the credit level approach degree of enterprise 7 is 0.6939 that is closest to standard object approach degree 1, so the credit level of enterprise 7 is the highest. The subsequent ones are enterprise 5, enterprise 6, enterprise 4, enterprise 3, enterprise 2 and enterprise 1. In comparison with the credit
evaluation indexes in Table 2, the indexes $c_5$ of enterprise 5 are highest. Comparing with enterprise 7, the index $c_1$, index $c_2$ and index $c_4$ are the secondary. The index $c_2$, index $c_5$, index $c_6$, and index $c_7$ of enterprise 1 are the lowest, so the credit level of enterprise 1 is the lowest. The sequencing accords with the actual credit of the 7 enterprises.

| Index | Enterprise 1 | Enterprise 2 | Enterprise 3 | Enterprise 4 | Enterprise 5 | Enterprise 6 | Enterprise 7 |
|-------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Approach degree | 0.4754 | 0.5862 | 0.5973 | 0.6280 | 0.6863 | 0.6367 | 0.7049 |

5. Conclusions
In the research on credit level of commercial circulation enterprises, fuzzy matter element model of Euclid approach degree is used to evaluate and analyze commercial circulation enterprises’ credit level referring to the fuzziness of evaluation indexes and incompatibility of indexes. To define index weights, expert investigation method and objective entropy weight method are integrated to be integrated weighting method. Overall considering subjective information and objective information, the actual credit level of commercial circulation enterprises can be well reflected. The key factors influencing credit of commercial circulation enterprises can be clearly known. At the same time, with good operability and high practical value, that supplies scientific basis and decision-making support for business and commerce department to raise credit level of commercial circulation enterprises.

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