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Integrity Evaluation of Customs Cooperation Based on Gray and Fuzzy Decision Theory

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Abstract. The integrity evaluation of cooperation does well to standardizing enterprise behavior, and constructing of an orderly competitive operating background. Evaluation term and method are most important in evaluation. In this paper, an evaluation system was designed, which included 3-level evaluation terms and a fusing optimized algorithm. During the course, multi-hierarchy analysis was used to design index structure firstly, and then the integrated Gray theory and Genetic algorithm were introduced to optimize index's weight. The innovation was reflected in article included an evaluation system with customs characteristics, and cooperation's integrity graded model based on quantitative evaluation.

Introduction

The integrity evaluation is one of the main and most effective tools, which is born in 1930s. [1] The integrity evaluation is used often to control integrity risk. Nowadays, abroad and some Asian developed countries have established social evaluation mechanism of integrity. But in China, the problem of discredit in enterprises is so prominent that the establishment of integrity is urgently needed. Integrity management began initially in finance [2] and then gradually generalized to numerous industries and departments.

The overseas research of the integrity evaluation can be traced back to Fisher, who used statistical methods to classify and evaluate people in 1936. After that, Beaver has used variable determination method to study the financial crises [3]. Besides, Hansen has used expert system to study the function of expert knowledge in integrity risk evaluation [4] and to simulate the evolution mechanism of integrity risk by technologies such as Neural Networks [5], Genetic Algorithm. From the end of the 1990s, domestic scholars have begun to discuss the issue of introducing the comprehensive evaluation system based on integrity evaluation into domestic corporation performance evaluation. Some of them introduced the non-financial index to corporation evaluation system from the angle of the management accounting. From the perspective of corporation management, Kemin and other scholars have studied comprehensive evaluation using the non-financial factors, such as financial index and investor protection [6]. Yang, Ke and some scholars have analyzed the research conditions of the financial crisis forecast of China, and have found that the introduction of non-financial index could increase the accuracy of the financial crisis forecast in quoted company by a wide margin [7]. Chen has summarized various comprehensive performance evaluation index systems both at home and abroad [8-9].

Integrity evaluation has been studied in various fields. Customs, as a most important entry and exit administration department, needs to manage corporations' integrity and promote the establishment of a society with integrity. The research about corporation integrity evaluation has got wide attention in academic world. The corporation integrity evaluation is mainly about quantitatively processing the corporation integrity degree by processing the evaluation index of integrity information from corporations and entrepreneurs using statistical method and related model ,which is based on the establishment of integrity evaluation index system and the construction and application of scientific and efficient integrity evaluation models and methods, aiming at solving the problem of information non-transparency between the bank and the corporation.

Design of Integrity Evaluation Index System

The connotation of customs corporation integrity evaluation, which is under the view of customs management, is not entirely equal to the general corporation integrity evaluation. This concept is based on general corporation integrity management. Meanwhile it expands the integrity connotation of the customs management requirement. So, customs integrity evaluation starts with the quality of integrity, namely from four integrity indexes-----the corporation's financial ability and management condition which stand for the ability of corporation integrity, the commercial credit of corporation represents integrity attitudes of it and the law-abiding condition of corporation represents credit behavior of corporation . In addition, the integrity connotation of customs emphasizes the importance of risk management by introducing two important aspects in customs management links, namely clearance risk index and tax risk index. However, index only reflects the quality of integrity. The quantity also needs to be used in distinguishing the degrees of integrity. The quantity of integrity means quantifying the index. To sum up, the establishment of index system and the quantization of index are the most essential and fundamental work in integrity evaluation.

Customs corporation integrity evaluation is based on general corporation integrity management. Meanwhile it is enriched with customs management. So, customs integrity evaluation starts with the quality of integrity. At the same time, rules of systematization, comprehensiveness, science, data availability, and stratification need to be obey in choosing index.

This paper has preliminarily constituted criterion layer and sub-criterion layer of evaluation index by analyzing the framework of evaluation index system and combining the existing research, and established integrity evaluation index system of Customs Corporation. As shown in Fig 1.

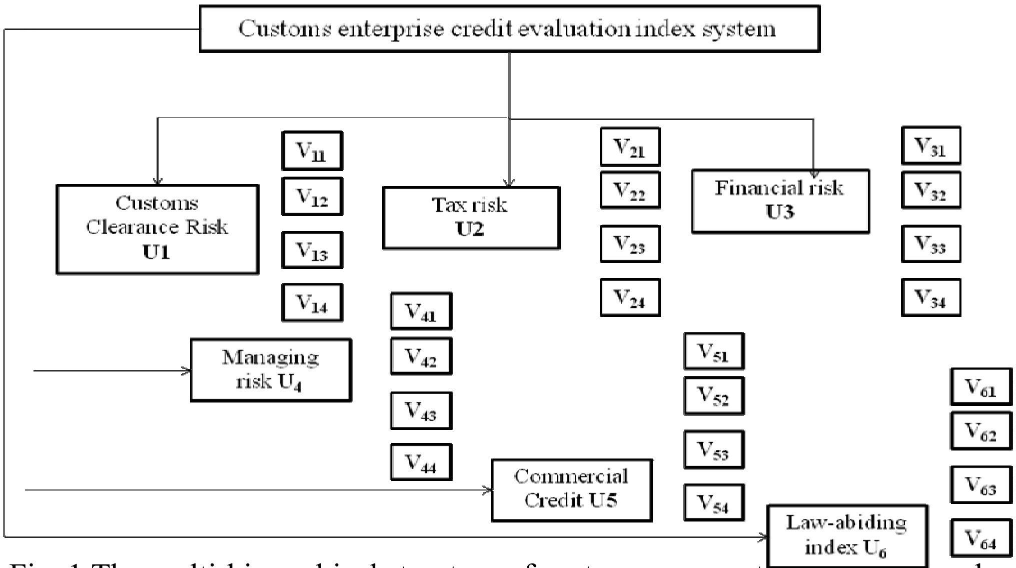

Fig. 1 The multi-hierarchical structure of customs cooperation integrity evaluation

In fig. 1, item U1 include V_{11} Declaration form pruning rate, V_{12} Declaration of express declarations single rate, V_{13} Declarations error rate, V_{14} Seized rate; U2 include: V_{21} Express tax rate, V_{22} Overdue tax ratio, V_{23} Tax relief ratio, V_{24} Tax reduction ratio; U3 include: V_{31} Quick Ratio, V_{32} Net Profit Margin, V_{33} Account payable turnover rate, V_{34} Assets Liabilities Ratio; U4 include: V_{41} Executive education degree, V_{42} Customs staff churns, V_{43} Executives' replacement, V_{44} Product return ratio; U5 include: V_{51} Defaults salary rate, V_{52} Overdue payment rate, V_{53} Debt disputes ratio, V_{54} Contract default rate; U6 include: V_{61} Intensity index of intellectual property rights, V_{62} Continuous smuggling of time ratio, V_{63} The smuggling strength index, V64 Liable to a fine ratio.

Application of Gray FAHP in Integrity Evaluation

The customs of corporation integrity risk evaluation is belonging to group decision of scheme ranking problems of management science. This kind of problem generally has characteristic of multi-index and multi-attributes, and the process of operation emphasized the importance of intuitive judgment of decision makers and the consistency of project comparison in the decision-making process because the evaluation results contains both quantitative index and qualitative indexes. This determines that the processing of this kind of problems need to be treated from three aspects, firstly is the quantification of qualitative indexes, secondly is scientifically and reasonably determination of weight of the index, the third one is the combination of the results based on index layering. From this, we can accurately sequencing the schemes.

Collection of evaluation index. The integrity risk evaluation index system of the customs corporation is $S=\{S_1,S_2,S_3,S_4,S_5,S_6\}$. among them, S_1,S_2,S_3,S_4,S_5,S_6 is the six subsets of it. Rank the evaluation index six subsets $S_{1j}(j=1,2,3,4)$, $S_{2j}(j=1,2,3,4)$, $S_{3j}(j=1,2,3,4)$, $S_{4j}(j=1,2,3,4)$, $S_{5j}(j=1,2,3,4)$, $S_{6j}(j=1,2,3,4)$ as 6 marks ----- 6,5,4,3,2,1.

The determination of weight of evaluation index

a. Evaluation result comes from experts from the fields of concerned areas, and produces evaluation judgment matrix A. Assume that the panel is composed of four experts, and each expert in the corresponding evaluation items is empowered as $\upsilon_t(t=1,2,3,4)$, g_t stands for knowledge ability, h_t represents professional ability, j_t is the familiarity of evaluation objects, and $\upsilon_t = g_t+h_t+j_t+k_t$. So the t-th expert's comprehensive credibility is $\sigma_t = \upsilon_t \Big/ \sum_{t=1}^{4}\upsilon_t$,$t=1,2,3,4$. The weight vector of the evaluation team composed of four experts is $W=(w_1,w_2,w_3,w_4)$.

b. Present the evaluation result in the form of judgment matrix. According to T. L. Satty's 1-9 scaling method , we can get the judgment matrix of two levels' indexes from the t-th expert by comparing evaluation indexes from each index set in the two-level index system in pairs with the 1-9 scaling method, which is relative to the entire evaluation item .

a_{ij} is generally determined by data statistics. Obviously, It should meet the following characters: property $a_{kk}=1$; inverse ratio property $a_{kj}=1\Big/a_{jk}$; consistency $a_{kj}=a_{kl}\Big/a_{jl}$.

The judgment matrix of indexes on the first level is $A_t=\left(a_{ij}^t \middle| i,j=1,2,3,4\right), t=1,2,3,4$. Among them, a_{ij}^t represents the relative importance of the t-th expert to evaluation index S_i and relative evaluation index S_j under the entire evaluation items. On the second level, the comparative judgment matrix in each index set is $A_{gt}=\left\{a_{gij}^t \middle| i,j=1,2,3,4\right\}$, among them $g=1,2,3,4,5,6$, $t=1,2,3,4$. Specifically, the second level have six evaluation subsets, as $A_{1t}=\left\{a_{1ij}^t \middle| i,j=1,2,3,4\right\}$, $A_{2t}=\left\{a_{2ij}^t \middle| i,j=1,2,3,4\right\}$, $A_{3t}=\left\{a_{3ij}^t \middle| i,j=1,2,3,4\right\}$, $A_{4t}=\left\{a_{3ij}^t \middle| i,j=1,2,3,4\right\}$, $A_{5t}=\left\{a_{5ij}^t \middle| i,j=1,2,3,4\right\}$, $A_{6t}=\left\{a_{6ij}^t \middle| i,j=1,2,3,4\right\}$. They represent the judgment matrix from the t-th expert's comparing of elements in the six two-level evaluation subsets in pairs.

c. The consistency test of the sequence and judgment of the importance degree in the index system. The elements of judgment matrix cannot have logic contradiction. for judgment matrix of order n , its largest characteristic root is single, and the largest characteristic root is $\lambda_{\max}\ge n$. When judgment matrix of order n is completely consistent, there is the only nonzero largest characteristic root $\lambda_{\max}=n$, and the rest of the characteristic roots are zero. When the judgment matrix cannot guarantee the complete consistency of it, its characteristic root will also change.

Assume that the determination process of the weight of the single sequence of the two layers of evaluation indexes determined by the t-th expert in the picture 1 is: on the first level w_k^t ,$k=1,2,3,4,5,6$, and also $w_k^t\ge 0$, $\sum_{k=1}^{6} w_k^t=1$; on the second level, it has 6 subsets $r=1,2,3,4,5,6$ whose weight of the single sequence are determined respectively as w_{rk}^t, and $w_{rk}^t\ge 0$, $\sum_{k=1}^{4} w_{1k}^t=1$. For every subset , the weight of the single sequence is w_{1k}^t $(k=1,2,3,4)$, and $w_{1k}^t\ge 0$ $\sum_{k=1}^{4} w_{1k}^t=1$; for k=2,3,4 is the same. Theoretically, on the first level $a_{ij}^t = {w_i^t}/{w_j^t}$ $(i=1,2,3,4)$, on the second level $a_{rij}^t = {w_{ri}^t}/{a_{rj}^t}$, $r=1,2,3,4,5,6$, $i=j=1,2,3,4$, so the 6 subsets are $a_{1ij}^t = {w_{1i}^t}/{a_{1j}^t}$, $a_{2ij}^t = {w_{2i}^t}/{a_{2j}^t}$, $a_{3ij}^t = {w_{3i}^t}/{a_{3j}^t}$, $a_{4ij}^t = {w_{4i}^t}/{a_{4j}^t}$, $a_{5ij}^t = {w_{5i}^t}/{a_{5j}^t}$ and $a_{6ij}^t = {w_{6i}^t}/{a_{6j}^t}$.

So the weight of single sequence of indexes on each level in A which determined by the t-th expert and the consistency test problem come down to a nonlinear optimization problem:

The first level: $\min CI^t(6) = \frac{1}{6}\sum_{i=1}^{6}\left|\sum_{k=1}^{6}\left(a_{ik}^t w_k^t\right) - 6a_i^t\right| \quad s.t \quad w_k^t \ge 0, k=1,2,3,4,5,6; \sum_{k=1}^{6} w_k^t = 1$ (1)

On the second level , there are 6 subset. For any one of the subset r, there are 4 evaluation indexes of it , so the way to test consistency of every subset is :

$$\min CI^t(4) = \frac{1}{4}\sum_{i=1}^{4}\left|\sum_{k=1}^{4}\left(a_{rik}^t w_{rk}^t\right) - 4w_{ri}^t\right| \quad s.t \quad w_{rk}^t \ge 0, k=1,2,3,4; \sum_{k=1}^{4} w_{rk}^t = 1$$

The first subset: $\min CI^t(4) = \frac{1}{4}\sum_{i=1}^{4}\left|\sum_{k=1}^{4}\left(a_{1ik}^t w_{1k}^t\right) - 4w_{1i}^t\right| \quad s.t \quad w_{1k}^t \ge 0, k=1,2,3,4; \sum_{k=1}^{4} w_{1k}^t = 1$ (2)

We can get the second to the sixth subset the same way: The sixth subset:

$$\min CI^t(4) = \frac{1}{4}\sum_{i=1}^{4}\left|\sum_{k=1}^{4}\left(a_{6ik}^t w_{6k}^t\right) - 4w_{6i}^t\right| \quad s.t \quad w_{6k}^t \ge 0, k=1,2,3,4; \sum_{k=1}^{4} w_{6k}^t = 1 \tag{3}$$

Formula (1) to (2) can be used to calculate the consistency of the judgment matrix problem. For the nonlinear optimization problem, the Accelerating Genetic Algorithm (AGA) will be easier and effective.

The weight of single sequence of indexes on each level in A which determined by the t-th expert and the consistency index function *CI* can be calculated by formula. Dim, $D=\left[w_k^t\right]_{4\times 6}$, $D_1=\left[w_{1k}^t\right]_{4\times 4}$, $D_2=\left[w_{2k}^t\right]_{4\times 4}$, $D_3=\left[w_{3k}^t\right]_{4\times 4}$, $D_4=\left[w_{4k}^t\right]_{4\times 4}$, $D_5=\left[w_{5k}^t\right]_{4\times 4}$, $D_6=\left[w_{6k}^t\right]_{4\times 4}$ are the group weight matrix of the four experts. But when *CI* is smaller than a standard value we consider the corresponding judgment matrix A_t and A_{gt} has satisfactory uniform solutions, and the weight of single sequence of all indexes w_k^t, w_{rk}^t are satisfactory; otherwise the original judgment matrixes A_t, A_{1t}, A_{2t}, A_{3t}, A_{4t}, A_{5t} and A_{6t} must be adjusted until the consistency test values of all judgment matrixes are smaller than the standard value.

d. The determination of the weight of the indexes of the two level index systems. We can get the weight vector of the evaluation index $S_i(i=1,2,3,4,5,6)$ which ultimately determined by the experts. $\sigma_{1\times 5}$ is the reliability index vector synthetically determined by the assessment ability of the experts themselves , $D_{4\times 4}$ is the group weight matrix of the four experts. We can get the weight vector of the evaluation index S_{1j} $(j=1,2,3,4)$ as $P_1=\sigma\cdot D_1=(P_{11}',P_{12}',P_{13}',P_{14}')$,

Expert Scoring Evaluation. Using the fuzzy analytic hierarchy process with two-layer structure, the 4 experts evaluate the two levels of index system of the evaluation object. According to the mark sheet filled in by experts, we can get the integrity evaluation matrix $E^B=\left[d_{ijk}^B\right]$, which represents the *k-th* expert's evaluation of the object *B* under the index S_{ij}. $E^B=\begin{bmatrix} e_{111}^E & \cdots & e_{114}^E \\ \vdots & \cdots & \vdots \\ e_{641}^E & \cdots & e_{644}^E \end{bmatrix}$

Determine the Gray Type of the Evaluation. When $m=4$, it means that comprehensive evaluation grade includes four rates as $R=1,2,3,4$, separately represents excellent, good, medium and bad. Their corresponding grayscale whiten functions is: The first gray type, excellent ($r=1$), set the gray number of it as $\odot_1 \in [4,\infty]$ and the whiten function as f_1. The second gray type, good ($r=2$), set the gray number as $\odot_1 \in [0,3,6]$ and the whiten function as f_2. The third gray type, medium ($r=3$), set the gray number as $\odot_1 \in [0,2,4]$ and the whiten function as f_3. The fourth gray type, bad ($r=4$), set the gray number as $\odot_1 \in [0,1,2]$ and the whiten function as f_4.

Calculate the Coefficient of the Gray Evaluation. For the evaluation index S_{ij} of evaluation object B, the evaluation coefficient of the r-th gray type is β_{ijr}^B. When $r=1$,

$$\beta_{ij1}^B = \sum_{k=1}^{4} f_1\left(e_{ijk}^B\right) = f_1\left(e_{ij1}^B\right) + f_1\left(e_{ij2}^B\right) + f_1\left(e_{ij3}^B\right) + f_1\left(e_{ij4}^B\right) \tag{4}$$

Similarly, we can get the expression when $r=2, r=3, r=4$, take r=4 as example,

$$\beta_{ij4}^B = \sum_{k=1}^{4} f_4\left(e_{ijk}^B\right) = f_4\left(e_{ij1}^B\right) + f_4\left(e_{ij2}^B\right) + f_4\left(e_{ij3}^B\right) + f_4\left(e_{ij4}^B\right)$$

The total coefficient of gray evaluation of each evaluation gray type related to evaluation index S_{ij} is $\beta_{ij}^B = \sum_{R=1}^{4} \beta_{ijr}^B$.

Calculate the Weight Vector and Weight Matrix of Gray Evaluation. For the evaluation object whose evaluation index is S_{ij}, all experts evaluate its gray weight of the *e*-th evaluation gray type as η_{ij1}^B, when $e=1$, $\eta_{ij1}^B = \frac{y_{ij1}^B}{y_{ij}^B} = \frac{y_{ij1}^B}{\sum_{r=1}^{4} y_{ijr}^B}$. Similarly, we can get the value when $r=2, r=3, r=4$, such as $\eta_{ij4}^B = \frac{y_{ij4}^B}{y_{ij}^B} = \frac{y_{ij4}^B}{\sum_{r=1}^{4} y_{ijr}^B}$. On account of that, for each gray type, the weight vector of gray evaluation of evaluation index S_{ij} is $\eta_{ij}^B = \left(\eta_{ij1}^B, \eta_{ij2}^B, \eta_{ij3}^B, \eta_{ij4}^B\right)$. Index S_{ij} makes S_i for the weight vector of gray evaluation in each gray type, and the gray evaluation matrix η_i^B in each evaluation gray type were described as following:

$$\eta_1^B = \begin{pmatrix} \eta_{11}^B \\ \eta_{12}^B \\ \vdots \\ \eta_{14}^B \end{pmatrix}, \eta_2^B = \begin{pmatrix} \eta_{21}^B \\ \eta_{22}^B \\ \vdots \\ \eta_{24}^B \end{pmatrix} \quad \eta_3^B = \begin{pmatrix} \eta_{31}^B \\ \eta_{32}^B \\ \vdots \\ \eta_{34}^B \end{pmatrix}, \eta_4^B = \begin{pmatrix} \eta_{41}^B \\ \eta_{42}^B \\ \vdots \\ \eta_{44}^B \end{pmatrix} \quad \eta_5^B = \begin{pmatrix} \eta_{51}^B \\ \eta_{52}^B \\ \vdots \\ \eta_{54}^B \end{pmatrix}, \eta_6^B = \begin{pmatrix} \eta_{61}^B \\ \eta_{62}^B \\ \vdots \\ \eta_{64}^B \end{pmatrix}.$$

Comprehensive Evaluation. For the evaluation result of the first grade, (Q_1, Q_2, Q_3, Q_4) are $Q_1^B = P_1 g \eta_1^B$, $Q_2^B = P_2 g \eta_2^B$, $Q_3^B = P_3 g \eta_3^B$, $Q_4^B = P_4 g \eta_4^B$. The total gray evaluation matrix of the integrity risk evaluation of Customs cooperation B is: $\Pi^B = \begin{pmatrix} Q_1^B \\ Q_2^B \\ Q_3^B \\ Q_4^B \end{pmatrix}$. So the comprehensive evaluation result of this corporation's integrity risk is

$$Q_h = P g \Pi^B \tag{5}$$

Calculate the Comprehensive Evaluation Value. Assumed that the grade value vector of each gray type is $C=(C_1, C_2, C_3, C_4)$. The comprehensive evaluation value of corporation B's integrity risk is $N^B = Q^B g C^T$. According to the value of N^B, the comprehensive integrity risk of enterprise B can be obtained.

Conclusion

Integrity evaluation of customs cooperation is studied in this paper. Compared with integrity evaluation study before, this paper aimed at constructing evaluation index systems with customs characteristic, screening evaluation methods, getting the results of ranking and analyzing evaluation results. By using this evaluation system, corporations can be managed differentially according to its integrity grade, which do good to prevent, control risk and carry on scientific management in management.

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