

Application of projection pursuit method based on accelerated genetic algorithm for evaluation model

Ding Yu

Department of Electrical Engineering, North China Electric Power University, Baoding, China

1847754222@ncepu.edu.cn

Abstract. In view of the evaluation decision-making problems of multi-index system such as supplier comprehensive evaluation, this article adopts the method of dimension reduction, namely using projection pursuit method based on accelerating genetic algorithm optimization. The algorithm can optimize the projection vector, let the high dimensional data through a certain combination of projection into the low dimensional subspace, and obtain the score of the sample from the projection function, so as to make scientific decision. This model avoids the interference of subjective factors to a large extent, and the evaluation results are more accurate and reliable, which provides a new method and thought for other evaluation and decision problems.

Keywords: Projection Pursuit Method, Accelerating Genetic Optimization Algorithm, Select Suppliers, Supply Characteristics.

1. Introduction

At present, the commonly used system evaluation methods include fuzzy comprehensive evaluation method, AHP method, grey correlation evaluation method and optimal comprehensive evaluation method based on feature vector. However, these algorithms have some problems such as information loss, evaluation results are affected by subjective factors, and poor adaptability to high-dimension and nonlinear evaluation problems. [1]

The projection pursuit method based on accelerated genetic algorithm (RAGA) optimization can compress multiple indexes into one-way indexes for evaluation, avoid the adverse influence of subjective factors on decision-making to a large extent, and solve the problem of global optimization of high-dimensional data, greatly reducing the workload. This paper will be applied to the problem of supplier selection faced by manufacturing enterprises.

2. Supplier evaluation model

2.1 The construction of evaluation index system

Under normal circumstances, the manufacturer has data on the quantity of orders and supplies from suppliers it has worked with in the past. Based on these data, the evaluation index system of supplier's supply capacity is constructed as follows:

Among them, A, B, C, D and E can reflect the quantity (capacity) of the supplier, the willingness of the manufacturer to choose the supplier and the previous cooperation stability between the manufacturer and the supplier. F and G can reflect the response ability of the supplier to the quantity of raw materials ordered by the manufacturer. The larger the value is, it indicates that the supplier often has the phenomenon of "demand exceeds supply", which will affect the normal production of the manufacturer to a certain extent, and it can also indicate the supplier's reputation level. Considering that in real life, different suppliers will provide different types of raw materials, and the comprehensive cost of various raw materials consumed by each unit product is different, which is equivalent to the different production costs caused by different suppliers. In other words, index H has a certain degree of influence on the economic benefits of enterprises.

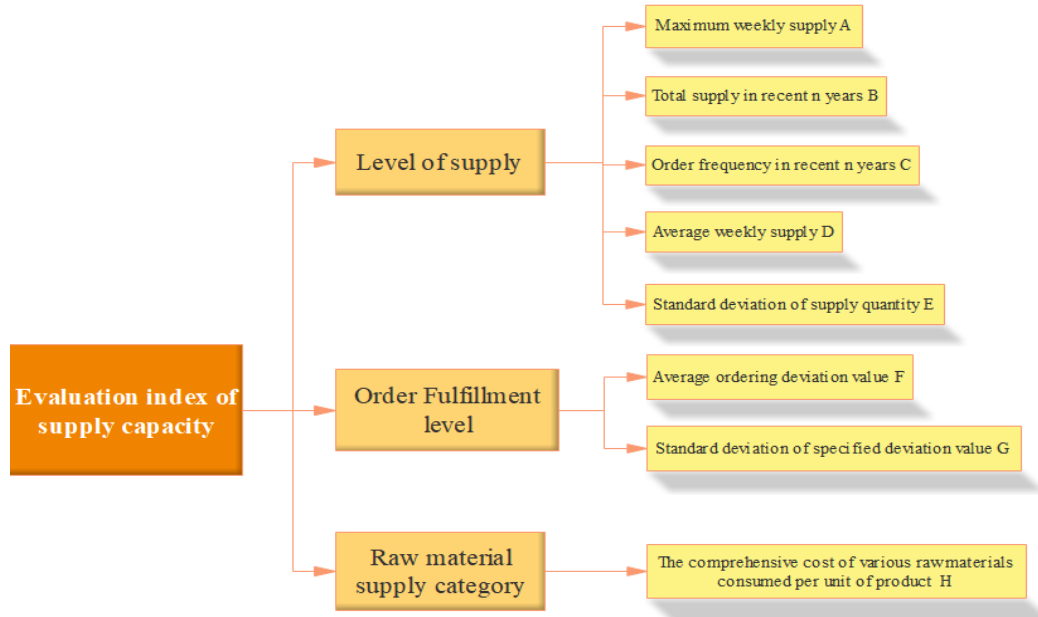


Figure 1. Evaluation index system

2.2 Quantitative calculation of evaluation index

1). Maximum weekly supply

The maximum supply of suppliers in recent n years.

2). Total supply in recent n years

Accumulation of supplier's weekly supply in recent n years.

3). Average weekly supply

Supplier's total supply quantity divided by total supply times in recent n years.

4). Order frequency in recent n years

The number of times a manufacturer has ordered raw materials from a supplier in recent n years.

5). Standard deviation of supply quantity

The standard deviation of supply quantity is obtained according to the average supply quantity of suppliers in recent n years.

6). The mean and standard deviation of the combined deviation determined by the prescribed deviation rate

Actual order deviation rate:

$$r_{os} = \frac{\text{order quantity} - \text{supply quantity}}{\text{order quantity}} \quad (1)$$

In order to reflect the fact that in the actual supply-demand relationship, the influence of the supply quantity less than the order quantity on the production of the enterprise is obviously heavier than the influence of the supply quantity greater than the order quantity, the order supply deviation value is set based on the actual order supply deviation rate:

$$\text{deviation} = f_{dev}(r_{os}) \quad (2)$$

Among them, r_{os} is the actual order deviation rate, $f_{dev}(r_{os})$ is prescribed for the deviation function:

$$f_{dev}(r_{os}) = \begin{cases} e^x - 1, & x \geq 0 \\ e^{-2x} - 1, & x < 0 \end{cases} \quad (3)$$

The function image is shown in Figure 2:

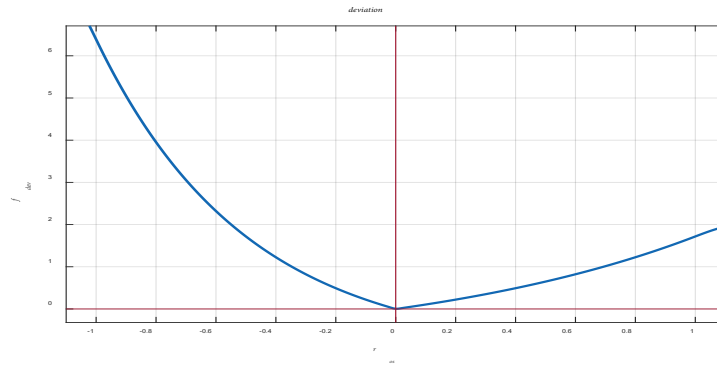


Figure 2. The function images

After the forward processing of the deviation function value, the average value and variance are calculated.

7). The comprehensive cost of A, B and C raw materials consumed per unit product

This paper sets the comprehensive cost of all kinds of raw materials consumed per unit product:

$$C_t = c_m + c_{ts} \quad (4)$$

Where, c_m is procurement cost, c_{ts} is transportation and storage cost.

2.3 Supplier evaluation model based on projection pursuit method [2]

Step1: Data processing

(1) Analysis of positive and negative direction of index

The positive and negative directivity of the indicators selected in this paper are different, so the positive and negative directivity of the indicators is analyzed first.

Table 1. Analysis of positive and negative direction of index

Index	(+/-)	Index	(+/-)
A	+	E	-
B	+	F	+
C	+	G	-
D	+	H	-

Positive processing of indicators with negative characteristics is carried out:

$$x_j = \max x_j - x_j \quad (5)$$

Where, x_j represents the value of column j indicator ($j \in \{0, 1, 2, \dots, 8\}$), and $\max x_j$ represents the maximum value of column j indicator.

(2) Normalization processing

In order to eliminate the influence of dimension, the data are normalized as follows:

$$x_j = \begin{cases} \frac{x_j - \min x_j}{\max x_j - \min x_j}, & \text{for positive indicators} \\ \frac{\max x_j - x_j}{\max x_j - \min x_j}, & \text{for negative indicators} \end{cases} \quad (6)$$

Where, x_j represents the value of column j index ($j \in \{0, 1, 2, \dots, 8\}$), $\max x_j$ represents the maximum value of column j index, $\min x_j$ represents the minimum value of the column j indicator.

Step2: Linear projection

Some initial projection directions $a = (a_1, a_2, a_3, \dots, a_m)$ are randomly selected to calculate the size of projection index. The solution of the projection of the maximum index is determined to be its

optimal projection direction, then the expression of the eigenvalue z_i of the projection of the z_i sample in one-dimensional linear space is:

$$z_i = \sum_{j=1}^m a_j x_{ij} \quad (7)$$

Step3: Construct projection index function

The definition of the optimal projection direction is different. This paper hopes that the distribution of projection eigenvalues $z_i (i = 1, 2, \dots, 8)$ can meet the requirements:

1. Local projection points are as dense as possible.
2. The projection point cluster is as far apart as possible as a whole. The construction objective function is:

$$\max Q(a) = S_a D_a \quad (8)$$

Where, S_a is the standard deviation of the projected eigenvalue, and D_a is the local density of the projected eigenvalue. The corresponding calculation formula is:

$$S_a = \sqrt{\sum_{i=1}^8 (z_i - \bar{z}_a)^2 / (n-1)} \quad (9)$$

$$D_a = \sum_{i=1}^n \sum_{j=1}^n (R - r_{ik}) f(R - r_{ik}) \quad (10)$$

Where, r_{ik} is the distance between projected eigenvalues, and $r_{ik} = |z_i - z_k| (i, j = 1, 2, \dots, n)$, $f(t)$ is a step signal and $f(t) = \begin{cases} 0, & t < 0 \\ 1, & t \geq 0 \end{cases}$, R is the window width parameter for estimating the local scatter density. According to the principle that at least one scatter point is included in the width, there are $\max(r_{ik}) < R < 2m$, for $i, k = 1, 2, \dots, n$.

Step4: Optimized projection direction

To sum up, the nonlinear optimization model can be obtained:

$$\begin{aligned} & \max Q(a) = S_a D_a \\ & \left\{ \begin{aligned} & S_a = \sqrt{\sum_{i=1}^8 (z_i - \bar{z}_a)^2 / (n-1)} \\ & D_a = \sum_{i=1}^n \sum_{j=1}^n (R - r_{ik}) f(R - r_{ik}) \\ & r_{ik} = |z_i - z_k| \\ & f(t) = \begin{cases} 0, & t < 0 \\ 1, & t \geq 0 \end{cases} \\ & \sum_{j=1}^m a_j^2 = 1 \\ & 0 < a_j < 1 \\ & \max(r_{ik}) < R < 2m \end{aligned} \right. \quad (11) \end{aligned}$$

This is a complex nonlinear optimization model, which is difficult to solve by general methods, so it is solved by accelerated genetic optimization algorithm [3]. Use the following statement to call the genetic algorithm in MATLAB [4]:

$$function [a, b, min, max] = RAGA(xx, N, n, Pc, Pm, M, DaiNo, Ci, ads) \quad (12)$$

Where: N is the population size; Pc is the crossover probability; Pm is the probability of variation; $DaiNo$ is the limit number set to accelerate once after two generations of evolution; n is the number of optimization variables; M is the random number required for the variation

direction, C_i is the acceleration times, ads equals 0 is the minimum, equals anything else is the maximum.

Step5: Solve the projection evaluation value

The optimal projection direction is used to calculate the projection index value of the sample:

$$z_i = \sum_{j=1}^m a_j x_{ij} \quad (13)$$

The projection index value is the supplier's comprehensive score. The higher the score, the more reliable the supplier is and the more inclined the enterprise is to cooperate.

2.4 Result analysis

By applying the data [5] of weekly supply and order quantity of 402 existing suppliers to a construction and decorative plate manufacturer in recent 5 years into this model, the optimal projection direction is obtained in this paper:

$$a = [0.414 \ 0.310 \ 0.566 \ 0.235 \ 0.577 \ 0.131 \ 0.007 \ 0.085]$$

Through in-depth data mining, this paper concludes that the total supply volume of the top 50 suppliers in the supply capacity scoring accounts for more than 90% of the total supply volume of 402 suppliers. It can be seen that the scoring of suppliers' supply capacity is reasonable and very effective. Therefore, the model established in this paper has strong reliability and high practical value.

3. Conclusion

It is an effective method for enterprises to carry out scientific management by using quantitative model for supplier evaluation and decision-making [6]. Based on the full analysis of the supply characteristics of suppliers, this paper establishes the supplier evaluation index system and constructs a scientific evaluation model to provide theoretical guidance and suggestions for the scientific decision-making of production enterprises. At the same time, the evaluation model constructed in this paper is also suitable for the evaluation of logistics companies and other suppliers when the order quantity and actual distribution quantity are known. Therefore, this model has important practical value.

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