Selection Method of the Demand Enterprises of Hydraulic Test-bed from the Perspective of Supplier

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Abstract: In order to solve the selection problem of the hydraulic test-bed demand enterprises for the supplier, firstly, this paper establishes the demander's evaluation index system from the perspective of the supplier and evaluates the demanders from seven evaluation indexes, such as payment price, payment speed and enterprise status; Secondly, the five level scale assignment method is used to obtain the weight of each index; Then, according to the specific demand information, the closeness of each demander is calculated and ranked by the ideal point method, so as to provide a reference for the decision-making of the supplier; Finally, the practicability of this method is illustrated by an example.

Keywords: hydraulic test-bed; Choice; Five level scale assignment method; Ideal point method

1 Introduction

Hydraulic pressure has been widely used in many industries due to its easy and great power transmission. Hydraulic test-bed is the main instrument for hydraulic test. Therefore, the design of hydraulic test-bed has drawn wide attention to scholars and experts. Peng X Z [1] and Li S [2] carried out relevant tests while the hydraulic test-bed was designed, which is in order to promoting the successful realization of the hydraulic test-bed. In addition, with the continuous development of higher education, many universities have opened hydraulic-related experimental curriculums. Relevant scholars have conducted design, research and development on hydraulic test-bed on educational aspect as well [3]. However, for those industries and enterprises which do not have independent R&D, design and manufacturing capability, purchasing hydraulic test-bed from the external is still the major choice. Academic circles have a lot of research results on supplier selection, which are significant guiding and reference both in theory and practice. In the current research on supplier selection, most of the consideration is how the demander selects supplier, but when thing goes reversely, the discussion is relatively lacking. High-quality products are often the target of demander’s preference, so, in this context, an objective situation arises: a supplier of hydraulic test-bed, due to its limited number of products, cannot satisfy all demanders in the face of multiple demanders and has to choose one from them to complete the transaction. Based on this situation, this paper establishes an evaluation system on the demanders, and evaluates them with corresponding model and algorithm,

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so as to provide a reference for the supplier's selection.

2 Model and algorithm

2.1 Construction of evaluation index system

When the supplier of hydraulic test-bed needs to make a choice from the demanders, screening reasonable evaluation indicators and establishing the corresponding evaluation index system is a key step. Analyzing the characteristics of both the supplier and the demander, combining with the selection criteria and principles of evaluation index, and basing on the previous research foundation, the evaluation index system of the demander is established as shown in Table 1 from the perspective of supplier.

Table 1. Evaluation index system of the demander

	Indicator name	Indicator meaning
Evaluation of the demander of hydraulic test-bed	Payment Price	The highest price that the demander is willing to pay for the supplier (￥10'000)
	Enterprise Ranking	The ranking of the demand enterprises.
	Credibility Degree	The credibility of the demander in the history of its transaction
	Payment Speed	The speed at which the demander pay for supplier (￥1'000/Day)
	Enterprise Status	The current operating conditions of the demander
	Cooperation Potential	The potential of the demander to cooperate in the follow-up development
	Communication & Cooperation	The communication and cooperation ability of the demander during and after the transaction

Among the above indicators, some indicators can directly obtain specific numerical data, such as payment price and enterprise ranking. Some indicators need to be calculated to obtain the indicator value, such as credibility degree and payment speed.

Supposing that a certain demander has reached transaction agreement with n suppliers in the historical process of its transaction, and in these n agreements, the number of breaches is a, so the number of successful transaction process is $n-a$. Furthermore, the account that it needs to be pay for the supplier for the i $(i = 1,2,\dots,n-a)$ time is ￥b_i, and the time for the settlement of the account is c_i days. Thus, the credibility degree$=\frac{n-a}{n}$, and the payment speed$=\frac{\sum_{i=1}^{n-a}\frac{b_i}{c_i}}{n-a}$. The other three indicators are fuzzy language evaluation indicators. In order to obtain quantitative evaluation values, this paper adopts the method of taking (very poor, poor, general, good, very good) $=$ $(0.1,0.3,0.5,0.7,0.9)$ to quantify them.

2.2 Selection method and model

In order to determine the weight of the evaluation indexes, the five scale evaluation method is adopted [4], and the specific steps are as follows.

1. Evaluation index assignment. Suppose the number of evaluation indicators is n, and d_{jk} represents the five-level scale value of indicator j to k. The assignment matrix D can be obtained by assigning values to the index set according to table 2.

Table 2. Five scale evaluation

Comparison of indicators	Value
Index j is super more important than k	$d_{jk} = 4 + 4, d_{kj} = 4 - 4$
Index j is much more important than k	$d_{jk} = 4 + 3, d_{kj} = 4 - 3$
Index j is obviously more important than k	$d_{jk} = 4 + 2, d_{kj} = 4 - 2$
Index j is slightly more important than k	$d_{jk} = 4 + 1, d_{kj} = 4 - 1$
Index j is as important as k	$d_{jk} = d_{kj} = 4$

$$D = (d_{jk})_{n\times n} = \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1n} \\ d_{21} & d_{22} & & d_{2n} \\ \vdots & & \ddots & \vdots \\ d_{n1} & d_{n2} & \cdots & d_{nn} \end{bmatrix}$$

2. The following formula is used to calculate the sum of the five scale values of the index.

$$s_j = \sum_{k=1}^{n} d_{jk} \tag{1}$$

3. The weight of the index is calculated by the following formula.

$$W = w_j = \frac{s_j}{\sum_{j=1}^{n} s_j} \tag{2}$$

The ideal point method [5, 6] is a method to make choice by calculating the closeness between the evaluation object and the ideal target value. It can better solve the selection problem. The specific steps are as follows.

1. Construct the initial matrix. Set the number of evaluation objects as m and the number of evaluation indicators as N, we can construct the following initial matrix.

$$R = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1n} \\ p_{21} & p_{22} & & p_{2n} \\ \vdots & & \ddots & \vdots \\ p_{m1} & p_{m2} & \cdots & p_{mn} \end{bmatrix}$$

2. Same trend processing. In the process of ideal point evaluation, the evaluation indicators are generally divided into positive and negative, so the original index value needs to be same trend processed. Use the reciprocal method, according to the following formula,

$$p'_{ij} = \frac{1}{p_{ij}} \tag{3}$$

We can obtain

$$R' = \begin{bmatrix} p'_{11} & p'_{12} & \cdots & p'_{1n} \\ p'_{21} & p'_{22} & & p'_{2n} \\ \vdots & & \ddots & \vdots \\ p'_{m1} & p'_{m2} & \cdots & p'_{mn} \end{bmatrix}$$

3. Standardized processing. After the same trend processing, through the following formula

$$p''_{ij} = \frac{p'_{ij}}{\sqrt{\sum_{i=1}^{m}\left(p'_{ij}\right)^2}} \tag{4}$$

We can get

$$R'' = \begin{bmatrix} p''_{11} & p''_{12} & \cdots & p''_{1n} \\ p''_{21} & p''_{22} & & p''_{2n} \\ \vdots & & \ddots & \vdots \\ p''_{m1} & p''_{m2} & \cdots & p''_{mn} \end{bmatrix}$$

4. Establish weighted normalization matrix. According to the weight of the evaluation indexes, the weighted normalization matrix can be obtained combining with R''.

$$V = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & & v_{2n} \\ \vdots & & \ddots & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \end{bmatrix} = \begin{bmatrix} w_1 p''_{11} & w_2 p''_{12} & \cdots & w_n p''_{1n} \\ w_1 p''_{21} & w_2 p''_{22} & & w_n p''_{2n} \\ \vdots & & \ddots & \vdots \\ w_1 p''_{m1} & w_2 p''_{m2} & \cdots & w_n p''_{mn} \end{bmatrix} \tag{5}$$

5. Determine the positive and negative ideal points by the following two formulas.

$$V^+ = (v_1^+, v_2^+, \ldots, v_n^+) = \left\{\left(max v_{ij}, j \in J^+\right), \left(min v_{ij}, j \in J^-\right)\right\} \tag{6}$$

$$V^- = (v_1^-, v_2^-, \ldots, v_n^-) = \left\{\left(min v_{ij}, j \in J^+\right), \left(max v_{ij}, \mathrm{j} \in J^-\right)\right\} \tag{7}$$

In the above two equations, V^+ represents the positive ideal point and V^- represents the negative ideal point; J^+ shows the positive evaluation index column and J^- shows the negative evaluation index column.

6. Calculate the distance by the following two formulas.

$$l_i^+ = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^+\right)^2} \tag{8}$$

$$l_i^- = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^-\right)^2} \tag{9}$$

7. Calculate the closeness and select. The following formula is used to calculate the closeness between the evaluation object and the ideal points,

$$C_i'' = \frac{l_i^-}{l_i^+ + l_i^-} \tag{10}$$

At this time, the one with the largest C_i'' value is closest to the ideal point, which is the best selection object.

3 Example

Take a hydraulic test-bed supplier as an example. It is known that after years of efforts and development, enterprise S, the supplier of hydraulic test-bed, can now develop, design and manufacture high-quality hydraulic test-bed and provide sales services for the market. Due to its good product quality and good reputation, at this time, five demander enterprises D1, D2, D3, D4 and D5 want to buy hydraulic test-bed from it, and they all expressed their strong willingness. In addition, through online search, expert evaluation, telephone communication and the demand materials provided by each demand enterprise to S, the specific demand information of the demanders is sorted out in Table 3. Based on this, the following will analyze the five demander enterprises to provide reference for the selection of S.

Table 3. Demand information of the demanders

Demander enterprise	Payment Price	Enterprise Ranking	Credibility Degree	Payment Speed	Enterprise Status	Cooperation Potential	Communication & Cooperation
D1	2.2	2	0.95	6.5	good	general	very good
D2	2.1	1	0.87	5	general	very good	good
D3	2.3	4	0.92	4.5	very good	general	general
D4	2.5	3	0.78	7	good	good	general
D5	2.4	5	0.88	6	good	general	good

3.1 Determination of index weight

For the seven evaluation indicators, carrying out five scale evaluation method, the following matrix is obtained.

$$D = (d_{jk})_{7\times 7} = \begin{bmatrix} 4 & 5 & 4 & 2 & 3 & 4 & 6 \\ 3 & 4 & 3 & 1 & 6 & 5 & 4 \\ 4 & 5 & 4 & 3 & 7 & 4 & 2 \\ 6 & 7 & 5 & 4 & 5 & 6 & 3 \\ 5 & 2 & 1 & 3 & 4 & 3 & 4 \\ 4 & 3 & 4 & 2 & 5 & 4 & 6 \\ 2 & 4 & 6 & 5 & 4 & 2 & 4 \end{bmatrix}$$

According to formula (1), $s_1 = \sum_{k=1}^{7} d_{1k} = 28$; $s_2 = \sum_{k=1}^{7} d_{2k} = 26$; $s_3 = \sum_{k=1}^{7} d_{3k} = 29$; $s_4 = \sum_{k=1}^{7} d_{4k} = 36$; $s_5 = \sum_{k=1}^{7} d_{5k} = 22$; $s_6 = \sum_{k=1}^{7} d_{6k} = 28$; $s_7 = \sum_{k=1}^{7} d_{7k} = 27$ can be obtained. According to formula (2), $w_1 = \frac{s_1}{\sum_{k=1}^{7} s_k} = 0.143$, $w_2 = \frac{s_2}{\sum_{k=1}^{7} s_k} = 0.133$, $w_3 = \frac{s_3}{\sum_{k=1}^{7} s_k} = 0.148$, $w_4 = \frac{s_4}{\sum_{k=1}^{7} s_k} = 0.183$, $w_5 = \frac{s_5}{\sum_{k=1}^{7} s_k} = 0.112$, $w_6 = \frac{s_6}{\sum_{k=1}^{7} s_k} = 0.143$, $w_7 = \frac{s_7}{\sum_{k=1}^{7} s_k} = 0.138$can be obtained too. So, the weight of the evaluation indexes $W(w_1, w_2, w_3, w_4, w_5, w_6, w_7)$=(0.143,0.133,0.148,0.183,0.112,0.143,0.138).

3.2 Evaluation and selection

According to the original demand information of the demanders, the language evaluation values are quantified and processed to form table 4 as follows.

Table 4. Demand quantification information of the demanders

Demander enterprise	Payment Price	Enterprise Ranking	Credibility Degree	Payment Speed	Enterprise Status	Cooperation Potential	Communication & Cooperation
D1	2.2	2	0.95	6.5	0.7	0.5	0.9
D2	2.1	1	0.87	5	0.5	0.9	0.7
D3	2.3	4	0.92	4.5	0.9	0.5	0.5
D4	2.5	3	0.78	7	0.7	0.7	0.5
D5	2.4	5	0.88	6	0.7	0.5	0.7

When TOSIS method is used for analysis, the evaluation indicators need to be treated with the same trend. Before this operation, it is necessary to classify the evaluation indicators into positive or negative types. From the perspective of the supplier, the classification of evaluation

indicators is shown in Table 5 below.

Table 5. Classification of evaluation indicators

Index Name	Positive Index	Negative Index
Payment Price	√	
Enterprise Ranking		√
Credibility Degree	√	
Payment Speed	√	
Enterprise Status	√	
Cooperation Potential	√	
Communication & Cooperation	√	

Because most of the above evaluation indicators are positive, when performing the same trend processing, we take the negative indicator to make them with the same trend as the positive according to formula (3). Then, table 6 is obtained after normalization processing due to formula (4).

Table 6. Demand information after same trend processing and normalization processing

Demander enterprise	Payment Price	Enterprise Ranking	Credibility Degree	Payment Speed	Enterprise Status	Cooperation Potential	Communication & Cooperation
D1	0.427	0.413	0.482	0.495	0.440	0.349	0.595
D2	0.408	0.827	0.441	0.381	0.314	0.629	0.463
D3	0.446	0.207	0.467	0.343	0.566	0.349	0.330
D4	0.485	0.276	0.396	0.533	0.440	0.489	0.330
D5	0.466	0.165	0.446	0.457	0.440	0.349	0.463

Combining the weight of each index, the weighted normalization matrix as shown below is established according to formula (5).

$$V = \begin{bmatrix} 0.061 & 0.055 & 0.071 & 0.091 & 0.049 & 0.050 & 0.082 \\ 0.058 & 0.110 & 0.065 & 0.070 & 0.035 & 0.090 & 0.064 \\ 0.064 & 0.027 & 0.069 & 0.063 & 0.063 & 0.050 & 0.046 \\ 0.069 & 0.037 & 0.059 & 0.098 & 0.049 & 0.070 & 0.046 \\ 0.067 & 0.022 & 0.066 & 0.084 & 0.049 & 0.050 & 0.064 \end{bmatrix}$$

Therefore, the positive and negative ideal points are obtained shown in table 7 through formula (6) and (7).

Table 7. Positive and negative ideal points

Demander enterprise	Payment Price	Enterprise Ranking	Credibility Degree	Payment Speed	Enterprise Status	Cooperation Potential	Communication & Cooperation
Positive ideal point	0.069	0.022	0.071	0.098	0.063	0.090	0.082
Negative ideal point	0.058	0.110	0.059	0.063	0.035	0.050	0.046

By using formula (8) and (9) for distance calculation, table 8 is obtained.

Table 8. Distance between demand enterprises and ideal points

Demand enterprise	Positive Distance	Negative Distance
D1	0.055	0.074
D2	0.099	0.045
D3	0.065	0.088
D4	0.048	0.085
D5	0.049	0.094

Calculate the closeness using formula (10) and sort it as shown in table 9.

Table 9. Closeness and ranking of demand enterprises

Demander enterprise	Closeness	Ranking
D1	0.575	4
D2	0.312	5
D3	0.576	3
D4	0.640	2
D5	0.659	1

According to the above, the demand enterprise D5 is the closest to the ideal point, which enterprise S should choose for trading.

4 Conclusion

Hydraulic test-bed is an important guarantee for the success of hydraulic experiments. For enterprises that do not have the ability to develop, design and produce hydraulic test-bed for the time being, they need to buy it from the external probably. High-quality products are often favored by consumers, so, there will be an objective situation that the supplier of hydraulic test-bed need to face multiple demanders and make a choice because of the limited number of its products. This paper establishes the evaluation index system of the demand enterprises from the perspective of the supplier, obtains the weight of the evaluation indexes through the five-level scale assignment method, and uses the ideal point method to evaluate the demanders, so as to provide reference for the selection of the supplier. The example shows that this selection method has good practical value.

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