QUALITY IMPROVEMENT FOR EXPERT BASE WITH CONTROL CHART TECHNIQUES*

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ABSTRACT: The axiomatic hypothesis of the objective distribution of evaluation subjection will be proposed in this paper. On the basis of that, set up the random response model of the expert evaluation system and the quality control principle of expert base. Under this principle, develop the statistical quality control theory of expert base, further; provide the quality improvement technology for expert base.

Key words: Expert base, Evaluation and decision-making, Quality control

INTRODUTION

So far, various kinds of expert bases according to their evaluation objects have been widely used in many evaluating and decision-making problems. Especially, they have played important rule in the evaluation of the science foundation projects organized by National Natural Science Foundation of China (NSFC) or other Bureaus or Agencies. In evaluating these projects of science foundation, expert base is an available tool, which is usually used in the two following ways:

- Direct use
- Indirect use

In the former, usually select five or six experts from an expert base randomly to assess the same project, these experts will independently rate

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the proposal of the project and the final decision can be made by surveying the judgments of the selected experts in advance in the expert base. In terms of the latter, set up an expert support system, which is as intelligent as evaluating experts in the expert base, because its model depends on the valuable acquirements by simulating the internal rules of every expert [1]. However, whether an expert base is in direct using or in indirect using, the quality of an expert base is played a decisive role in evaluation. The better quality of an expert base is, the more unbiased the final judgment is. What is the quality of an expert base? It depends on the contributions of every expert in the expert base. Because experts are influenced by many factors in assessment processes such as, their psychology fluctuation, knowledge, experience and talent, the evaluating results from these experts can't get their ideal true values or objective values, but usually fluctuate around the true values respectively [2,3]. The variation or unconformity of an expert will cause the quality of the evaluated results, and the differences among them will result in the quality problem of an expert base so that the final judgment is incredulous or even false.

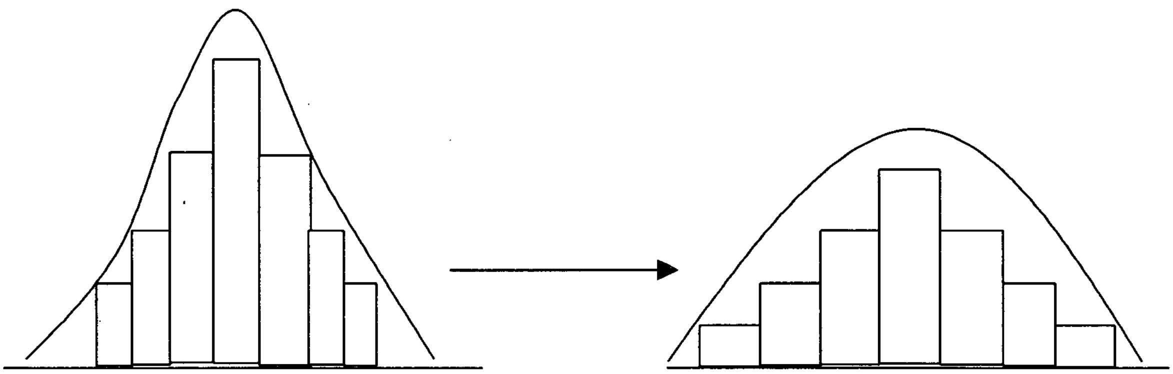
In practice, it is very much difficult to rule out completely the variations in expert evaluation, and even if every expert's variation is scanty, but the differences among expert variations are obvious which still cause the quality problem of evaluating or decision-making. Therefore, an expert base being of high quality should be as follows.

- The fluctuation caused with an expert's evaluating around its ideal true value should be as minor as possible.
- The differences among the evaluating results from the several experts should be less enough.

The quality control for expert bases is to reduce the variations and minimize the differences continuously. So far, the entire variation theory about expert bases has not been seen, and the corresponding quality control technology has not been discussed. This paper will first come up with the axiomatic hypothesis of the objective distributions of expert evaluations. Second, on the basis of this, set up a random response model of the expert evaluation system and the quality control criteria of expert bases. Under this principle and statistics, we provide the quality theory of expert bases. Finally, the quality improvement techniques for expert base are introduced. The main contribution of this paper is that the evaluation and decision-making based on human subjective judgment are combined effectively with the theories and methods of statistical quality control and quality design idea in engineering, and the specific statistical theory and method about quality control for expert base are presented.

THE AXIOMATIC HYPOTHESIS ABOUT THE OBJECTIVE DISTRIBUTION OF THE SUBJECTIVE EVALUATION

Evaluation and decision-making have usually to divide into two steps. First one is to set up criteria and then to measure the criteria. A large number of products and parts need to be measured in the same long-run production. After the measurable characteristics X are determined, there will exist some objective probability distribution of X, shown as Fig.1 (a). This ideal distribution which precisely describes the real state of production is called as the objective distribution of production processes. In practice, this objective distribution is obtained by measuring the criteria or characteristics X with gages. The distribution which is formed by the measurements with given gage is regarded as the measurement distribution, as seen as Fig.1 (b).



(a) The objective distribution (b) The measurement distribution

Fig.1 The measurement distribution's variation is greater than the Objective distribution's

Since any gage has to be influenced by the random factors, gages are of themselves errors. Usually, the measurement distribution's variation is greater than that of objective distribution, shown as Fig.1. This fluctuation of the measurement distribution comes form two parts: one is the variation of the objective distribution, and the other is the gage errors. For the same objective distribution, different gages result in different measurement distributions. When using a much precise gage, the measurement distribution should be closely identical to the objective distribution. In the project evaluation, the projects in the same area are very similar to the products or parts in the industrial production processes. From the given criteria, the projects, whether is good or bad, must have its objective distribution. In order to obtain its measurement distribution, the gages which are used are just experts. The measurement distribution is the statistical distribution formed by experts' evaluating values in a great number of projects. The objective distribution of projects in the same area is independent of the gages or the experts. On the other hand, in evaluation or decision-making, experts in an expert base are put on an equal footing, that is, they have the same opportunities to assess the projects. Now come up with the axiomatic hypothesis of the objective distribution of subjective evaluation.

Axiomatic Hypothesis: There must exist *objective distribution* of the projects *in the same evaluation field. Every expert in the same expert base must be of an identical objective distribution*

THE RANDOM RESPONSE MODEL OF EXPERT EVALUATION SYSTEM

Under the axiomatic hypothesis, though all group of projects to be assessed by every expert in the same expert base have an identical distribution, why are the probability distributions from the expert evaluation still different to some extent? The main reason is that the evaluating results of every expert are not only limited by the objective distribution, but also influenced by other two kinds of factors. One kind is random factors, such as the psychological factors, environment and acquirement of uncompleted information. It is these factors that cause the occasionality of expert's evaluating results. The other kind is system factors, for example, expert's knowledge area , talent, special experience, a certain degree of observation ability , as well as his depth in research work. These system factors and the objective distribution of input (criteria or characteristics) X come up to the probability distribution of the evaluating results, as seen as Fig.2. The distribution of X is known as the objective distribution, which is independent of any expert. The distribution of output (response) Y is relying on the objective distribution and experts. Since the expert evaluating system are influenced by the random factors, the variation of response Y, denoted as σ_y, are obviously greater than that of input X which is written as σ_X, and the relationship between them as follows.

$$\sigma_Y=\sigma_X+\sigma_E$$

Where σ_E is the error variation caused by random factors of experts.

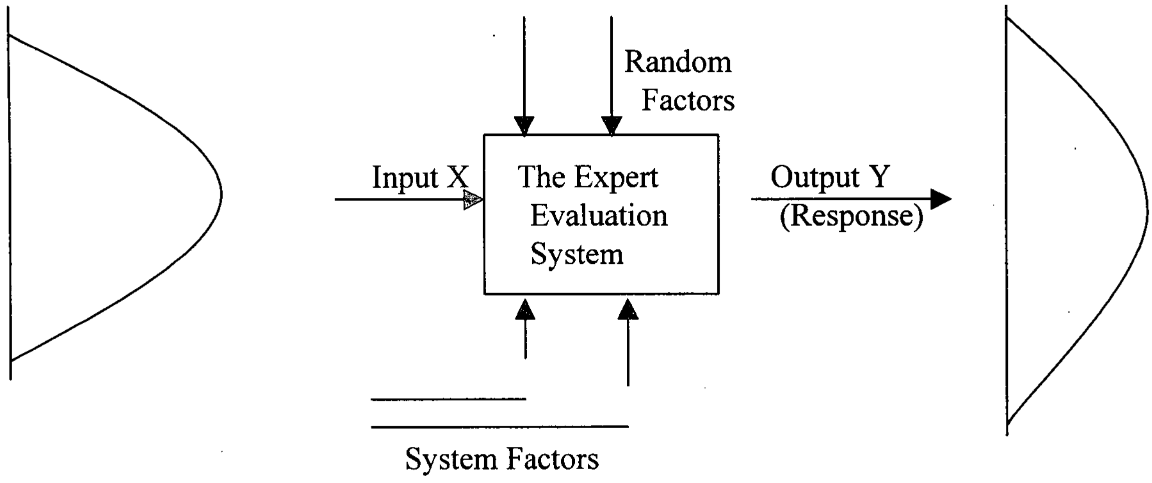


Fig.2 The random response model of the expert evaluation system

In evaluation, for the given evaluation characteristics X, the evaluation result Y usually fluctuates around its real value t = E [Y/ X] [2,3] with the random errors ε_X , that is, Y_X= E[Y/ X] + ε_X . E [Y/ X] is the conditional expectation of Y about X. Obviously, $D(Y_X) = D(\varepsilon_X) = \sigma^2_E$, where $D(Y_X)$ is the variance of Y_X. Therefore, the expert variation σ^2_E is just the variance of Y_X. Here σ^2_E is only related to the random factors coming from the expert, but have nothing to do with X. When $\sigma_E = 0$, the expert is regarded as a high quality exert. When the variations of every expert in an expert base are all equal to zero, the expert base is of high quality, which is a perfect expert base. σ_X describes the variations of the projects group to be evaluated which exist in objective realistic world. In quality control for expert base, we cannot eliminate σ_X and it is not necessary to reduce σ_X. on the above discussion, the goal of quality control for expert bases is as follows:

- Reduce the expert variation σ_E;
- Minimum the differences among expert variations σ_E

The former will be discussing in next chapter and the latter will be shown as last chapter.

QUALITY IMPROVEMENT FOR EXPERT BASE WITH CONTROL CHARTS

The first goal to improve the quality of an expert base is to reduce the expert variation σ_E. In a given expert evaluation process, an objective distribution exists in reality, which can't be changed at any time. The system factors shown up experts' internal characters, such as their talent, special experience, knowledge structure, are too difficult to change. It is impossible that robust design is implemented directly for the evaluation system to reduce the variation σ_E by means of the engineering techniques of robust design. An available method to control the quality of expert base is to rule out the experts fluctuated greatly in evaluation.

From the axiomatic hypothesis, it is known that if all of experts in an expert base are qualified, the probability distributions generated by the evaluation results under the same objective distribution are identical or approximate. The objective distribution can be estimated by data that are accumulated in the long evaluation, which is denoted

By $\hat{X}$. The estimations of the mean and variance of the distribution, $\hat{E}(X)$ and $\hat{D}(X)$ are obtained respectively. Usually, the objective distribution is a

distribution, and every distribution of expert evaluation results is identical

distribution or an approximate normal distribution $N(\hat{E}(X), \sqrt{\hat{D}(X)})$. Therefore, t

use of the Shewhart Principle [4], the control chart for improvement of

distribution of evaluating results from expert base which are made up of all exp

expert base is constructed as follows:

evaluating data is also the normal distribution $N(\hat{E}(X), \sqrt{\hat{D}(X)})$. Further maki

$$UCL = \hat{E}(X) + 3\sqrt{\hat{D}(X)},$$

$$CL = \hat{E}(X),$$

$$LCL = \hat{E}(X) - 3\sqrt{\hat{D}(X)}$$

The evaluating values from experts are plotted on the control chart in turn, as shown in Fig.3. Experts are ranked according to the number of the points beyond the limits, and discard the experts who are of the most points out of control, and the others' evaluating results have smaller variations and better conformability.

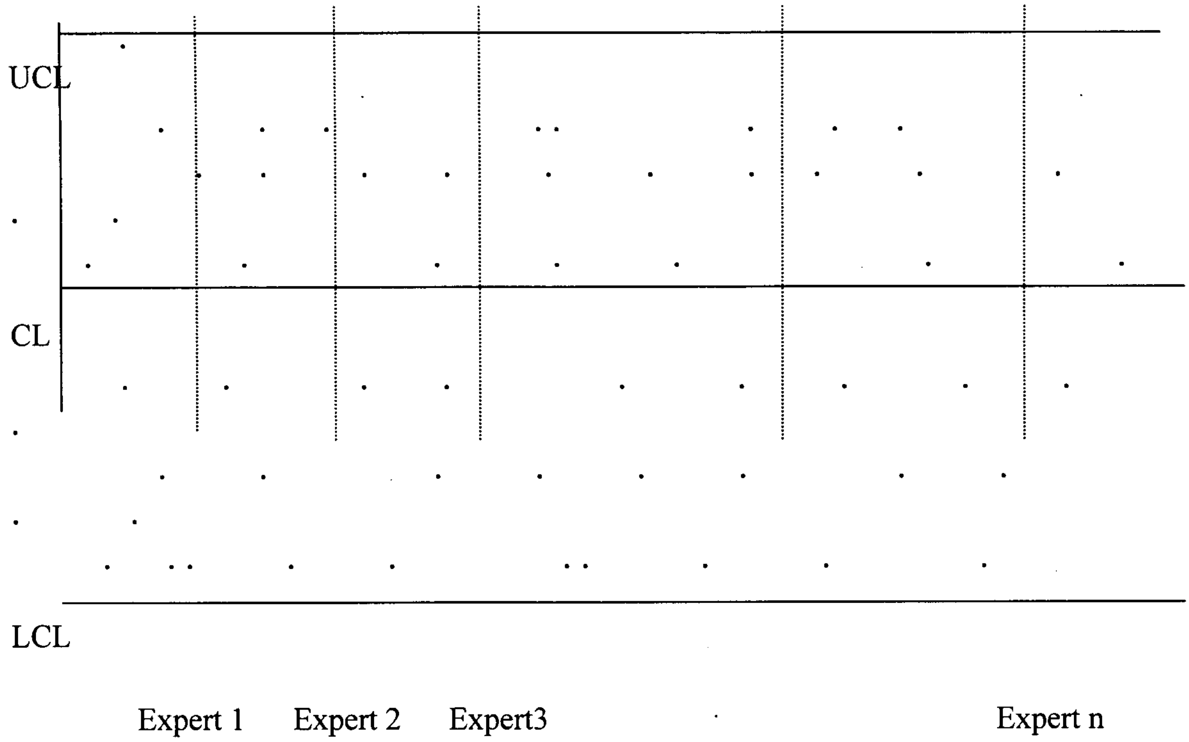


Fig.3 The control chart for quality improvement of expert base

In real assessment, the evaluating results from every expert in an expert base can be

divided into some groups, and then the general range average $\overline{R}$ of the evaluating values from the expert base is estimated. Making use of $\hat{E}(X)$ and $\overline{R}$, a mean-range

control chart is constructed in order to improve the quality of expert base. The mean chart shows the deviation between expert evaluating results Y and the objective true value E (X), and range chart comes up with the variations from the evaluating results of every expert. The experts who have more points out of control in both mean and range charts should be ruled out so as to assure the evaluation quality of expert base.

Another method improved directly the quality of expert base is used boxplot chart [5], that is, the evaluating values of each expert correspond to a small square or box, and eliminate the experts which the center lines in their corresponding boxes deviate from

$\hat{E}(X)$ and the boxes are wider.

THE SAME DISTRIBUTION PRINCIPLE AND ITS IMPLEMENTATION

The second goal to improve the quality of expert base is to eliminate the differences among experts in evaluation. In real assessment and decision-making, the evaluating values from several experts get together and make the final decision by means of comparison. It is the differences among the experts' variations that result in the unreasonableness of the comparison. In order to eliminate the differences such that different expert evaluating values have the same evaluation standard, it is necessary that different experts have the identical evaluation base and conformability as well as preference which are described precisely by the moments from one dimension to three dimension in statistics. It is obvious that the moments of high dimension shown other evaluation characteristics should be equal for different experts. As long as the various moments of dimensions are equal corresponding to experts, it is asserted that the evaluating values from different experts should have the same distribution.

The Same Distribution Principle: *In comparison with the evaluating values from different experts, these evaluating values should have the same distribution.*

On the above discussion, it is best way to correct the various moments of different experts so as to implement the same distribution principle, that is, deal with the evaluating values from different experts so that various kinds of data have the identical moments. In practical applications, it is common to correct the evaluating base E (X) and conformability D (X) with the standard transformation in order to implement the same distribution principle. The standard transformation for the evaluating values, Y, is the following.

$$Z = \frac{Y - E(Y)}{\sqrt{D(Y)}}$$

The data after transformed, Z, has the identical moments of one dimension and two dimensions, and Z is regarded as the same probability distribution approximately. These evaluating values can be combined together and then the priority of evaluation results is ordered by comparison, finally, the reasonable and unbiased the decision is made.

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