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Research on mathematical statistics application in geological survey and mineral processing

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ABSTRACT

The paper takes mine survey as research objects, by utilizing documents literature, numerical analysis and mathematical statistics as well as others to analysis coal mine survey, in order to adapt to practical requirement, it amends traditional mathematical statistics method, after improving, it is more reasonable to practice, therefore it can better meet demands of production and living, and the model can reduce work load and meanwhile get maximum survey result so that can well promote its economic efficiency, speed up survey schedule, shorten time, which has reference values for relative field development in future. In addition, the paper analyzes Hebei one place optimal silver mine selection plan, by utilizing mathematical statistics method, it gets that regarding silver mine constructive plan merits and efficiency type indicators present a kind of positive correlation state, and meanwhile it also gets model modification avoids humanistic subjective factors interference, which lets its evaluation result to have more rationality, and meanwhile also let model to become more simple.

KEYWORDS

Mathematical statistics; Coal mine survey; Optimal plan; Mathematical model; Economic efficiency.

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INTRODUCTION

With rapidly development of science and technology, social pace also ceaseless speeds up, now it creates conditions for mathematical statistics development, in scientific research process, we will get involve I many random variables, distribution features description and other correlation problems, and now mathematical statistics just a set of mathematical tool that describes random variables and mutual relationships, how to let mathematical statistics method to better adapt to scientific research, data analysis always plays extremely important roles on it.

Regarding mathematical statistics aspect research, many scientific researchers have made efforts and contributions, such as Guan Shi-Han in the article of regarding mathematical statistics analysis and application, she had every pointed out that applied statistical method, started from statistical contents, now statistics development plays more and more important roles in current social politics and economy aspects, the idea plays certain promotion roles in current social development; Xu Bo and others in regarding customs statistical analysis had ever put forward that established rule base to describe statistical analysis core problems, due to customs data was complex, analysis contents were more and unchecked, so used mathematical statistical method had important significances in government decision making, guiding customs legal operation and instructing customs regular working.

The paper just on the basis of formers research, further analyzes mathematical statistics method, and applies it into survey and mine selection aspects, by applying information consulting method, questionnaire survey, numerical analysis method and others, creates new flavors for surveying and mine selection aspects, and builds theoretical foundation for the field development.

MATHEMATICAL STATISTICS MODEL THEORETICAL ANALYSIS

Assume there are n piece of indicators are evaluated, corresponding calculation numerical value is x_{ij} from which j=1, 2, $\cdots$, m, it represents each indicator serial number, from which m represents it has m pieces of indicators to evaluate, and i=1, 2, $\cdots$, n, represents number of plans. It can solve comprehensive index by defining x_{ij} weight coefficient, that:

$$y_i = b_1 z_{i1} + b_2 z_{i2} + \cdots + b_m z_{im} = \sum_{j=1}^{m} b_j z_{ij} \tag{1}$$

Among them, Z is obtained matrix by observing initial data, that is :

$$Z = \left\{ z_{jk} \right\}_{n \times m} \tag{2}$$

After that, according to above formula size, we can judge the indicator merits, by the method, it defines plan that most conforms to practice. Plan comprehensive indicator is Y, then it has:

$$Y = \left[y_1, y_2, \cdots y_n \right] \tag{3}$$

By above process, we can know that if define the optimal plan according to Y, then it needs to arrive at large dispersion effect in each indicator as much as possible, so that it can be of great help to implement people decision plans, so in order to implement plan modification, it must let Y sample variance to arrive at maximum values, from which sample variance formula is :

$$S^2 = \frac{1}{n} B^T AB \tag{4}$$

Handle with initial data by normalization, we can get corresponding covariance matrix is :

$$A = Z^T Z \tag{5}$$

In order to let sample variance to arrive at maximum value, it needs to let symmetric matrix's positive semi-definite matrix to arrive at maximum feature value, and needs to do unitization handling with it and get corresponding feature vector.

If one item coefficient difference is extremely big, it proves the indicator contribution rate on evaluation indicator influence extent will also be very big, now it presents mutual positive correlations, and one indicator coefficient and other indicators weights coefficients present opposite relationships, then the indicator presents negative correlations, the method overcomes experts subjective factors, is a kind of ideal experts mathematization model.

Mathematical statistics calculation process

Targeted at the paper, it can get that constructive plan can be divided into two forms, one of them is cost type indicator that indicator value get smaller, the result will be better, another one is efficiency type indicator that indicator value gets bigger, the result will be better, between the two is a kind of opposite relations, in order to define comprehensive selection plan, the paper converts the two, the orientation is converting the first type indicator into the second type indicator, from which :
Cost type is:

$$x'_{ij} = x_{\min j} / x_{ij} \tag{6}$$

And efficiency type is:

$$x'_{ij} = x_{ij} / x_{\max j} \tag{7}$$

In above formula, $x_{\min j}$ and $x_{\max j}$ respectively represents the j indicator minimum and maximum values. Firstly do normalization processing with above covariance, its matrix with standard variance as 1, average value as 0 is:

$$z_{ij} = \frac{x'_{ij} - \overline{x}_j}{S_J} \tag{8}$$

$$\overline{x}_j = \frac{1}{n} \sum_{i=1}^{n} x'_{ij} \tag{9}$$

$$S_j = \frac{1}{n} \sum_{i=1}^{n} (x'_{ij} - \overline{x}_j)^2 \tag{10}$$

After that, calculate matrix A, then it has:

$$Z = \{z_{jk}\}_{n \times m} \tag{11}$$

$$A = Z^T Z \qquad (12)$$

Then calculate matrix A maximum feature value feature vector weight coefficient vector B, finally process with above process, it can get comprehensive index size, and then rank it and can get optimal solution.

Mathematical statistics application in geological survey

For survey net density, make quantization research by mathematical statistics method, it can utilize mathematical statistics variance and average value to estimate total numeric variance value and learning expectation value, by different survey nets densities, it solves their corresponding savings error efficiency η, then it can utilize solved error $\varepsilon = \eta * \overline{x}$ range's probability $1 - a = p\{|\overline{x} - a| < \varepsilon\}$, which is also coal bed average thickness's a confidence interval in $(\overline{x} - \varepsilon, \overline{x} + \varepsilon)$, accordingly if its confidence level probability is $1 - a \geq 95\%$, then it can use $\overline{x}$ to replace a, thereupon solves whole savings size.

Savings calculation formula is:

$$Q = S \bullet \sec \phi \bullet M \bullet D \qquad (13)$$

Among them, D—— triangle capacity `ton/cubic meter`
M—— Every layer thickness average value
ϕ—— Area average inclination angle average value, (`degree`)
S——Horizontal area (`ten thousand square meter`)
Q—— Savings (`ten thousand ton`)

By above, we can get every layer thickness average value, coal capacity average value, coal bed inclination angle average value and every layer horizontal area jointly decide coal savings Q size, and in practical coal savings calculation process, coal bed inclination angle average value and every layer horizontal area, coal capacity average value changes are very small, so coal bed average thickness is a factor that decides coal savings. For each savings error rate calculation, domestic and foreign have no unified standard form, the paper through consulting relative information, establishes a standard grade table, as following TABLE 1 shows.

TABLE 1 : Coal savings grade standard table

Grade	Confidence probability	Allowable error value
A	> 90	10
B	$80 - 90$	20
C	$70 - 80$	40
D	$50 - 70$	60

For different coal fields savings each phase, it adopts certain survey net density to ascertain corresponding grades savings as each grade savings precise, it can solve coal bed thickness errors average values.

If for one survey net density, it can assign each coal bed thickness numeric value that are respectively $x_1, x_2 \cdots x_n$. Every section coal bed thickness can use arithmetic average value to express as :

$$\overline{x} = \frac{1}{n} \sum_{i=1}^{n} x_i' \qquad (14)$$

By above formula we can use it to replace coal bed actual average thickness, then it requires quantities to be as many as possible, estimated variance to be as small as possible, obtained estimation quantity should be approximate to actual numeric value, but the two always have deviation :

$$|\overline{x} - a| < \varepsilon \tag{15}$$

Among them, ε assignment is up to different savings, corresponding precise should conform to different grades corresponding requirements as :

$$\varepsilon = \eta * \overline{x} \tag{16}$$

Corresponding estimated range is in :

$$(\overline{x} - \varepsilon) \leq \alpha \leq (\overline{x} + \varepsilon) \tag{17}$$

Due to above estimation quantity is a kind of random one, the condition to make it true is :

$$p\{|\overline{x} - a| < \varepsilon\} = 1 - a \tag{18}$$

In above formula: $(\overline{x} - \varepsilon, \overline{x} + \varepsilon)$—— a Confidence interval
$1 - a$—— Confidence coefficient probability
a—— Risk degree or reliability
So, the paper introduces standardized statistical quantity calculation equation:

$$\mu = \frac{\overline{x} - a}{\sigma / \sqrt{n}} \tag{19}$$

According to probability theory's correlation theory, we can get normal random variable's variance is 1, expectation is 0, and corresponding σ^2 unbiased estimator is $\frac{n}{n-1} S^2$, and input the formula into standardized statistical quantity, we can get its new statistical quantity equation is :

$$t = \frac{x - a}{S / \sqrt{n-1}} \tag{20}$$

For given confidence interval, it has $(\overline{x} - \varepsilon, \overline{x} + \varepsilon)$, therefore it can solve corresponding statistical quantity t_0 size.

Due to $\varepsilon = -\dfrac{t_0 S}{\sqrt{n-1}}$, by above, we can get $\varepsilon = \eta * \overline{x}$, so we have:

$$t_0 = -\frac{\eta \overline{x}}{S / \sqrt{n-1}} = -\frac{\eta \overline{x}}{\sqrt{\dfrac{1}{n(n-1)} \sum\limits_{i=1}^{n} (x_i - \overline{x})^2}} \tag{21}$$

According to above formula, we can solve freedom degree and statistical quantity's t distribution bilateral critical value, therefore solve risk degree, reliability and confidence coefficient probability sizes.

In reality, due to survey net density gets bigger, corresponding reliability will also correspondingly get bigger, coal bed average thickness will increase with whole coal bed thickness increases, and different thicknesses and corresponding grades savings precise reliability have no certain connections to seek, allowable variance and corresponding statistical quantity present a kind of positive correlations. In order to get closer to practice, it can use allowable errors to replace original errors, therefore obtain corresponding formula as:

$$t_0 = -\frac{\eta \square \overline{x}}{S / \sqrt{n-1}} \tag{22}$$

It can also change into:

$$t_0 = -\frac{\eta \square C}{S / \sqrt{n-1}} \tag{23}$$

For different coal beds, corresponding constant C are different, but by consulting relative information, we can get its range is in $(1.0 \sim 1.2)$, assignment size is changing with standard deviation changes.

Take Hebei one region coal mine as an example to explain, for selected coal mine hole number, it makes quantization statistical analysis according to 500m, 1500m, 3000m, 1000m, 2000m line space, when line space is one thousand, corresponding error rate is $\eta = 0.1$, it carries on statistical test, its process is as following :

(1) $n = 51$ represents corresponding hole number;

(2) $N = 2.66$ represents hole number per square kilometer;

(3) $\overline{x} = \frac{1}{n}\sum_{i=1}^{n} x_i = 2.9$ represents coal bed thickness mean value

(4) $\sum_{i=1}^{n}(x_i - \overline{x})^2 = 12.85$ represents sum of squares of deviations

(5) $S = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \overline{x})^2} = 0.5$ represents sample's standard deviation value

(6) $\varepsilon = \eta * \overline{x} = 0.29$ represents error

(7) $t_0 = \dfrac{\eta \overline{x}}{\sqrt{\dfrac{1}{n(n-1)}\sum_{i=1}^{n}(x_i - \overline{x})^2}} = 4.09$ represents statistical quantity size

By above, we can solve corresponding result is risk degree $a = 0.005$, confidence coefficient probability $1 - a > 0.95$. After that, we apply improved method can get its result as :

(1) $n = 51$

(2) $N = 2.66$

(3) $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i = 2.9$

(4) $\sum_{i=1}^{n}(x_i - \bar{x})^2 = 12.85$

(5) $S = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2} = 0.5$

(6) $C = 1.13$

(7) $t_0 = \dfrac{\eta\bar{x}}{\sqrt{\dfrac{1}{n(n-1)}\sum_{i=1}^{n}(x_i - \bar{x})^2}} = 1.58$

By above result, we can get when freedom degree as 50 confidence coefficient $1-a = 0.9$, risk degree $a = 0.1$.

To sum up:

By above, we can get Hebei one coal mine mathematical statistical obtained result is :grade C savings is 3000m, grade B savings is 2000m, grade A savings is 500m.

After improving mathematical statistics method, we can get:grade C savings is 2000m, grade B savings is 1000m, grade A savings is 500m.

And actual savings survey result is :grade C savings is 2000m, grade B savings is 1000m, grade A savings is 500m that is the same as solved results, it proves the model's rationality and effectiveness, but in order to more reasonable safety produce, the paper suggests the region to adopt grade C savings as 1500m~2000m, grade B savings as 750~1000m, grade A savings as 375~500m.

Mathematical statistics application in gold mine selection plan

The paper takes Hebei province silver mine selection as its research objects, relevant experts set four kinds of plans to select, evaluate financial provided data, and summarize indicators into following TABLE 2:

TABLE 2 : Silver construction plans' important indicators

Type	Each indicator	Plan I	Plan II	Plan III	Plan IV
	Earnings after tax /%	22	26	37	30
	Investment interest rate /%	15	16	24	21
	Investment income /%	14	15	23	20
	Gross value after tax / ten thousand Yuan	443	669	1495	3215
Efficiency type	State tax revenue /ten thousand Yuan	4754	5010	5965	22452
	After-tax profits /ten thousand Yuan	7241	7821	9545	39216
	Annual tax sum /ten thousand Yuan·a^{-1}	59	56	62	167
	Average profit /ten thousand Yuan	541	583	714	3652
	Annual output value /ten thousand Yuan	2754	2715	2842	8865
	Dynamic payback time after tax /a	12	10	7.8	10.6
Cost type	Static payback time after tax /a	6.7	6.5	5.4	6.8
	Silver cost /ten thousand Yuan·kg^{-1}	6.5	6.3	5.9	5.6

Silver mine cost / $\mathrm{Yuan} \Box t^{-1}$	242	198	158	1632
Annual average cost /t en thousand Yuan$\Box a^{-1}$	2014	1998	1845	5621
Gross investment /t en thousand Yuan	5145	4987	3725	16445

According to mathematical statistics method, the paper selects efficiency type nine indicators, cost type six indicators as research objects, according to previous stated status, it can get maximum feature value $\lambda_{max} = 17.119$, corresponding feature vector B is:

$$B = \left[-0.29, -0.12, -0.13, -0.13, -0.08, 0.54, 0.33, 0.44, 0.22, 0.39, 0.45, 0.42, 0.43 \right]^{T}$$

Input the vector into above formula, we can get every plan evaluation indicator vector Y is :
$$Y = [0.141, 0.121, 0.167, 0.155]$$

By the vector, we can get each plan evaluations indicator numeric values, therefore get each plan merits are respectively :III, IV, I, II, so we can get best plan is III.

By consulting relative information, we can rank above methods, get result as following TABLE 3 shows:

TABLE 3 : Rank comparison table

No.	1	2	3	4
Mathematical statistics	y_4	y_3	y_1	y_2
Information a	y_4	y_3	y_2	y_1
Information b	y_4	y_3	y_1	y_2

The paper selected mathematical statistical model obtained result is the same as consulted information result, and in information b, third and fourth ranking are just opposite, it proves mathematical statistical evaluation result is consistent to fuzzy grey element plan, and from the paper we can get that apply mathematical statistics plan into processing is more convenient.

By above feature value, we can get efficiency type indicators and obtained result ranking present a kind of positive correlation trend, the value gets bigger, then obtained ranking result will be more foreword, and targeted cost type indicators and obtained result ranking present a kind positive correlation, so it proves dynamic investment payback time, gross investment, unit silver mine cost amount, annual cost number, static investment payback time and unit golden cost amount numerical values get bigger, then rank order will be more backward, the result just matches to practical economic rules in reality, so it proves mathematical statistical model superiority.

By calculated weight coefficient, we can get comprehensive evaluation indicator has maximum influences on investment return rate and annual output value. And meanwhile it also reflects efficiency type indicators silver mine construction plane merits evaluation indicator takes economic interest as its measurement criterion.

By table, we can get that in profit and tax investment ratio, investment return rate and internal return rate several plans, the maximum one is plan III, its result is 8.05% higher than peer, and around 20% higher than required in evaluation, the plan corresponding profit balance point is in case when output is 189 kilogram, is lower than previous two plans, if silver price reduces, the plan is still major in profit in certain range. The result proves mathematical statistics superiority that lets obtained result to conform to practice; the plan is fit for adopting.

CONCLUSION

Targeted at mathematical statistical method and its application in coal mine, we can get:

The paper can get that mathematical statistics after improvements is more reasonable with practice by coal mine survey result, therefore it can better meet production and living demands, and the model can reduce work load and meanwhile get maximum survey result, so that it can well promote its economic efficiency, speed up survey schedule, shorten time, which has important significances in relative field development in future.

Targeted at mathematical statistics method and its application in silver mine selection plan, we can get:

i, By taking Hebei province one place silver mine as an example, select best plan, it proves mathematical statistical model is a kind of epitome of evaluation digital model, its advantage is it avoids humanistic subjective factors interference, let its evaluation result to have more rationalities, and meanwhile it also let model to become more convenient.

ii, By above process, we know that if it wants to establish a best plan, it must select a kind of multiple-target decision plan, by consulting relative information, we can find relative information is quite a lot, but each method has its shortcomings, so to avoid such status, the paper selects to make selection of multiple evaluation plans in concrete examples, and makes modification on proper plans, therefore it can get its comprehensive analysis best plan.

iii, By above process, we get that regarding silver mine constructive plan merits and efficiency type indicators present a kind of positive correlation state, it proves mathematical statistical comprehensive evaluation model is consistent to selected plan analysis result, the result just conforms to practical status.

REFERENCES

[1] Wei Zhong-Shu; Probability theory and mathematical statistics course [M]. Beijing: Higher education press, **(2008)**.

[2] Xu You-Zhi, Mao Shan-Jun, Wang Jing-Hua; Quantitative coal mine survey science [M], Xu Zhou: China Mining University, **(1994)**.

[3] Tang Ji-Min; How mathematical statistics to establish into unified independent statistics [J]. Vocational education and economic research (Journal of Loudi vocational technological college), **1**, **(2006)**.

[4] Anhui coal mine geology bureau the third survey party. Liuqiao the second coal mine mining geological report [R1, Huaibei, **5**, **(2001)**.

[5] Gu Ju-Chuan; Briefly analysis of mathematical statistics application in data screening [J]. Inner Mongolia statistics, **1**, **(2009)**.

[6] Zhang Fu-Zhen; Discuss on Jiangsu drift ice Aijingshan mountain silver mine survey net measurement rationality [Jiangsu geology, **20(4)**, 23-235 **(1996)**.

[7] Yang Hai-Jie; Application of mathematical statistics method[J]. Journal of Chengde medical college, **4**, **(2005)**.

[8] Zhao Li-Mian; Strengthen "probability theory and mathematical statistics" applied teaching [J]. China education innovation herald, **11**, **(2009)**.

[9] Ding Hai-Jun, Li Guo-Cheng; Oil-gas field development plan comprehensive evaluation new method [J]. Natural gas industry, **16(4)**, 29-31 **(1996)**.

[10] Chen Jian-Nan; Mathematical statistics and other management techniques applied practices in enterprises operation decision [J]. Enterprise science and technology development, **6**, **(2008)**.

[11] Zhang Shu-Qiu; Fuzzy optimization theory application in optimal selection oil-gas field development plan [J]. Natural gas industry, **13(2)**, 45-48 **(1983)**.

[12] Cai Lun-Meng; Mathematical statistics method application in high speed road subgrade engineering quality control [J]. Value engineering, **11**, **(2009)**.

[13] Xiao Fang-Chun; Fuzzy grey element optimization theory application in optimal selection oil-gas field development plan [J]. Daqing oil geology and development, **14(3)**, 31-35 **(1995)**.