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THE AHP APPLIED TO COMPREHENSIVE EVALUATION OF DEVELOPMENT

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IN this paper, used the principle of the AHP, criterion system for comprehensive evaluation of development project in oil field is constrcted, and seventeen specific index of development projuct is determed on index hierarchy. After analysing fuctionlal and structural dependence of the system, We consider that this system is an hierarch structure with feedback, that is critrion and subcriterion hierarchy have internal dependence, and there is circlar dominat relation between in them. In terms of judgment matrices which were provided by experts, making used of geometric mean method by which group judgments are syn thetised, we obtained group priority setting weightvecter for factors of each hierarchy, then, making use of priority setting of complex system -supermatrix theory, we obtained limiting weights of specific index in index hierarchy. In accordance with synthetic scoring method, we can find synthetic scoring value of dictinct projects, with which optimal project is choosed. Project example is showed that this new decision method has clear to think simple and prictical and optimizing consequence has higher confidence.

intrduction

The prospecting and exploiting work in oilfield have some specile features with a much investment, much larger risk, much complexer afected factors much longer time, and so on, then for one reasonable development project which guides carring out prospecting and exploiting works above-named many factore as a geology conditions exploiting way, investment expenses, economical and social effectiveness and so on must be consided comprehesively. these factors are concerned with varous areas (social, economical, technical, engineering and so on), they are inter--conected and restrain each other. Multi-index which find expression in these affecting factors must be constructed and make up a scientific eva

luating index system, for comprehrsivelly studing and completely evaluating development projects from above, it is show that this system , has two featurs, 1. involves many qualitave factors(as in geology conditions, exploiting way, social effectiveness and so on), these factors can't be expressed precisellу and definited with convention mathmatic method, people only can make judgment by oneselves experience and knowledge; 2, In this multi-index system, various index is not treated the same by peaple on different objects and demands, but peale endows certain weight according to their relative important degree on evaluating system, these weights shall affect evaluating result derectly. Therfor, it is extremly important problem for us to find new scientific method expressing decision and judgment numericallу, and also difining weights of various index objectivelly. Then, the AHP, with respect to its sceintific spirit on theory and practicality on method, can just efficiently solves above problems. Expressing gualitative factors numericallу and deferming weights of various index with the AHP in reseaching comprehensive evaluation of exploiting project in oil field, we have obtained comparatively satisfy result.

1. the AHP Applied to Comprehesive Evaluation of Exploiting Project in Oilfield

From above, development project in oilfield is a mult-index system. Befor now, only having relied on obscure comprehesion and forming intuition based on accumulating experiences in practice, people could research this complex systematic problem, or has consider simply few index, but also has ignoed many factors which decide excellent or bad of development projects. Obviously, thus obtaining evaluating result lacks of scietific spirit and brings with large one-sidedness, therefor always makes a mistake of decision. Along with putting into demecracization and sciencization of decision, people paie great attention to making use of comprehesive evaluating method with scientific multi-index, then , the AHP just can give for us this scientific method of practical decision. Following, we shall discuss problem of comprehesive evaluation of exploiting

1>To Construct Mode With the AHP and Caculate Weghts of Evaluating criteria

①. To Establish Hierarchy Costruct Evaluating Index System

For efficiently making use of experience and knowledge of experts and bring into being democracization and sciencization of decision, adopting the form to consult with experts, we establish hierarchy construct so that decision is in keeping with objective rull. According to discussing opiong of the various experts who are versed in petroleum geologe, programming and desing and so on, we constructed hierarchy structures for comprevesive evaluating system of exploiting project in oilfield(as in Figure 1).

In Figure 1, A: Comprevesive Evaluation of Oilfield Development Project B1: Dividing Exploiting layer series
B2: Driving Method; B3: Well Patter; B4: Oil Prodcton Technologe; B5: Acccumilating and Transporting Technology of Gas-oil; C1: Effectiveness; C2: Expenses; C3: Recovery Ration; C4: Oil Production Ration; C5: Comprehesive Water cut; D1: Economic Effecttiveness; D2: Social Effectiveness; D3: Gross Investment of Oilfield Construction;
D4: Oil Production Cost; E1: Dynamic State; E2: Static State; F1: Net Preset Value; F2: Dynamic Recuvery Time; F3: Internal Rate of Return; F4: Recuvery Time of Investment; F5: Net Revenue or Profit; F6: Investment Effect; F7: Stable Production Time of Oilfield; F8: Environmental Production; F9: Utilization of Three Waste; F10: Investment of Exploiring and Drilling; F11: Gross Investment of Ground Constrution; F12: Investment of Men Expenses and Equipments; F13: Unpredictable Expenses.

From Figure 1, it is showed that objuctive hierarchy indicates comprehesive evaluationg to exploiting projects in oilfield so as establishing optimal exploiting project. Thus, we have to consider both demand on state constrution and development for enterprise, and have to take economical effectiveness seriously also analyze its social effectiveness, simultaneously, have yet to notice of investment in development projuct and exploiting level. Finally, sevety evaluating indeces are infered by induction.

There, importance of each element on every hierarchy in total evaluating system is different, but thy hardly expresse with number precisely, however, according to oneself knowledge and experience, experts of areas

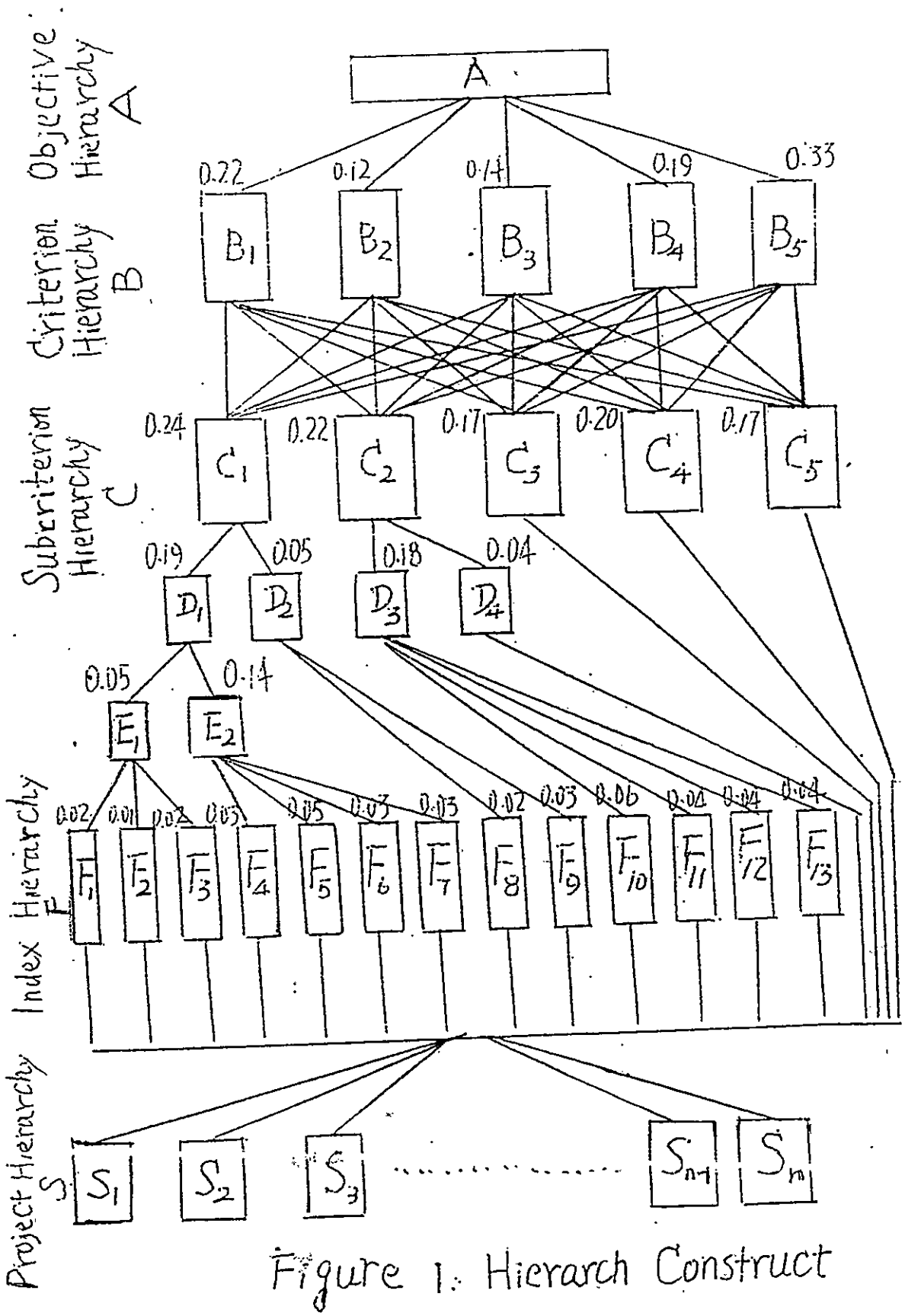

Figure 1: Hierarch Construct

can make judgment, and construt judgment matrices and find their weight scientificlly.

② Construct Judgment Matrices and Hierarchy Single Ordering, Calculate Relative Important Weights of eachy element on Every Hierarchy.

We yet adopting the form to consult with experts, construct judgment matrices. Through the medium of consult with ten experts, and cumulating group judgment matrices, making of geometric mean method to synthesise, we can obtain comprehesive judgment matrices of every hierarchy finally.

Procedure of geomatric mean method is following:

a), For accumulated judgment matrices

$$A=(a_{ij}^{(s)})_{n\times n} \qquad s=1,2,\cdots,k \quad i,j=1,2,\cdots,n$$

To calculate

$$a_{ij}=\sqrt[K^*]{\prod_{s=1}^{K^*} a_{ij}^{(s)}} \qquad (a_{ij}^{(s)}>0)$$

There,

a), , indecate for s expert to make judgment on relative important betreen i factor and j factor;

k^*, indecate nonzero numbex factors among a .

b), To find maximal characteristic root and conrrespording eighenvector of comprehesive judgment matrices $A=(a_{ij})_{n\times n}$ in accordance with characteric root method.

Eeventually, we have found comprehesive judgment matrices and hierarchy single ordering, and all consistency inspecting is satisfind for us. We only liste results of single ordering as table 1, 2, 3, 4, 5.

table 1, A-B, B-B, C-B single ordering

	A	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
B1	0.22	0.48	0.24	0.33	0.25	0.18	0.17	0.13	0.21	0.26	0.31
B2	0.12	0.09	0.29	0.10	0.07	0.10	0.10	0.06	0.26	0.13	0 08
B3	0.14	0.12	0.08	0.30	0.13	0.18	0.16	0.12	0.15	0.21	0.25
B4	0.19	0.17	0.21	0.15	0.31	0.23	0.25	0.34	0.25	0.31	0.23
B5	0.33	0.15	0.18	0.14	0.25	0.31	0.32	0.35	0.13	0.10	0.12

table 2: B-C, C-C, single oedering

	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
C1	0.34	0.10	0.12	0.23	0.14	0.43	0.25	0.22	0.17	0.20
C2	0.21	0.19	0.31	0.26	0.31	0.18	0.39	0.19	0.12	0.06
C3	0.14	0.41	0.12	0.17	0.11	0.17	0.13	0.30	0.21	0.10
C4	0.16	0.16	0.23	0.24	0.12	0.11	0.12	0.12	0.33	0.29
C5	0.16	0.14	0.23	0.11	0.32	0.12	0.11	0.16	0.17	0.35

table 3: C-D, D-E single ordering

	C1		C2		D1
D1	0.78	D3	0.82	E1	0.27
D2	0.22	D4	0.18	E2	0.73

table 4: single ordering

E-F	E1	E_2-F	E2	D_2-F	D2	D_3-F	D3
F1	0.32	F4	0.20	F8	0.49	F10	0.36
F2	0.27	F5	0.51	F9	0.51	F11	0.20
F3	0.40	F6	0.23			F12	0.24
		F7	0.22			F13	0.21

③ To construct supermatrix

In hierarchy construct of eveluating development projuct in oilfield, there is mutuale dependeces among evary factors on criterion subcriterion hierarchy. For example, on criterion hierarchy in order to exploiting petroleom resources maximally, dividing of development layer series driving method, well pattern, oil production technology have mutual dependece. Similarly, for subcriterion hierarchy considering comprehesive effectiveness, investment expense, recovery ration, oil production rate, and comprehesive water cut are mutual dependece. Besides, there is mutual affection between criterion and subcriterion hierarchy . Therefor, they are considered circalar which have internal dependece .Making use of judgment matrices and single ordering results of criterion and subciterion hierarchy, we can estblisch their supermatrix, that is table 5.

table 5, supermatrix of B and C hierarchy

	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
B1	0.48	0.24	0.33	0.25	0.18	0.17	0.13	0.21	0.26	0.31
B2	0.09	0.29	0.10	0.07	0.10	0.10	0.06	0.26	0.13	0.08
B3	0.12	0.08	0.30	0.13	0.18	0.16	0.15	0.15	0.21	0.25
B4	0.17	0.21	0.15	0.31	0.23	0.25	0.34	0.25	0.30	0.23
B5	0.15	0.18	0.14	0.25	0.31	0.32	0.35	0.13	0.10	0.12
C1	0.34	0.10	0.12	0.23	0.14	0.43	0.25	0.22	0.17	0.20
C2	0.21	0.19	0.26	0.31	0.31	0.18	0.39	0.19	0.12	0.06
C3	0.14	0.41	0.12	0.17	0.11	0.17	0.13	0.30	0.21	0.10
C4	0.16	0.16	0.23	0.24	0.12	0.11	0.12	0.12	0.33	0.29
C5	0.16	0.14	0.23	0.11	0.32	0.12	0.11	0.16	0.17	0.35

To weight for above supermatrix(as in table 5), we have to find affeting ordering of B and C hierarchy. Found result is showed as in table 6

table 6, affecting ordering of B and C hierarchy

A	B	C	W
B	1	0.76	0.43
C		1	0.57

With above result(as in table 6), we can estblisch weighting supermatrix, that is table 7

table 7, weighting supermatrix.

	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
B1	0.21	0.10	0.14	0.10	0.08	0.07	0.06	0.09	0.11	0.13
B2	0.04	0.13	0.04	0.03	0.04	0.04	0.03	0.11	0.06	0.04
B3	0.05	0.04	0.13	0.05	0.08	0.07	0.05	0.07	0.09	0.11
B4	0.07	0.09	0.07	0.13	0.10	0.11	0.14	0.11	0.13	0.10
B5	0.07	0.08	0.06	0.11	0.13	0.14	0.15	0.06	0.04	0.05
C1	0.19	0.06	0.07	0.13	0.08	0.25	0.14	0.13	0.10	0.11
C2	0.12	0.11	0.18	0.15	0.18	0.10	0.22	0.11	0.07	0.03
C3	0.08	0.23	0.07	0.10	0.06	0.10	0.07	0.17	0.12	0.06
C4	0.09	0.09	0.13	0.14	0.07	0.06	0.07	0.07	0.19	0.17
C5	0.09	0.08	0.13	0.06	0.18	0.07	0.06	0.09	0.10	0.20

Making use of weighting supermatrix, we can find W^{∞}, found result is showed as in table 8.

table 8: W^{∞}

	B1	B2	B3	B4	B5	C1	C2	C3	C4	C5
B1	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.11	0.11	0.11
B2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
B3	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
B4	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
B5	0.09	0.09	0.09	0.10	0.09	0.10	0.10	0.10	0.09	0.09
C1	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
C2	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.12
C3	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
C4	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.11	0.11	0.11
C5	0.10	0.10	0.11	0.10	0.11	0.11	0.10	0.10	0.10	0.11

From above(as in table 8), we can find limiting ordering weights evary elements on subcriterion hierarchy for criterion hierarchy, that is (0.14, 0.13, 0.10, 0.11, 0.10). Normalizing it, we can find (0.24, 0.22, 0.17, 0.20, 0.17).

④. Hierarchy Synthetic ordering

As in Figure 1, single ordering of B hierarchy even is her syntretic ordering, based on synthetic ordering of B and limiting ordering of C hierarchy, we have found synthetic ordering of C, that is table 9.

table 9: synthetic ordering of C hierarchy

B / C	B1	B2	B3	B4	B5	W
	0.22	0.12	0.14	0.19	0.33	
C1	0.24	0.24	0.24	0.24	0.24	0.24
C2	0.22	0.22	0.22	0.22	0.22	0.22
C3	0.17	0.17	0.17	0.17	0.17	0.17
C4	0.20	0.20	0.20	0.20	0.20	0.20
C5	0.17	0.17	0.17	0.17	0.17	0.17

Afterwards, making use of synthetic ordering of evary subhierarchy, we have obtaind synthetic ordering of index hierarchy. The weights of synthetic ordering for each element on evary hierarchy are maked nearby corresponding element on evary hierarchy(as in Figure 1)

1. Project Example Analysis

The comprehesive evaluating key for exploiting project with the AHP is determing weights of evaluating index. Have found weights, we then can use of formula

$$D_i = \sum_{j=1}^{n} W_j \cdot P_{ij} \qquad (1)$$

To find synthetic scoring value of distinct projects, choosing then project which has maximal value in D is regarded as optimal one.

In formula(1), D_i , the synthetic scoring value of i project;
P_{ij} , the scoring value of i project for j index;
w_j , the weight of j index;

Following based on researching result for the AHP, making use of synthetic scoring method , we make compprehesive evetuating for feasible exploiting project on some development areas of Dagang oilfield.

Having analyzed oil pool and geologic fetures, determed reserves parameter and cucalated reserves, researched tested data of well, finally, researchers worked out five development project of this areas and reduced to ten evaluating indices(as in table 10).

table 10, indices of five project (I, Index ; P, project)

I / P	F1	F2	F5	F4	F6	F7	D3	C4	C3	C5
I	9687.5	2.3	12880.0	2.3	493.3	10	2962	1.0	9.87	54.6
II	17250	1.5	20451.4	1.5	761.5	9	3024.5	1.5	13.31	68.0
III	19626.5	1	22425.6	1.4	829.9	5	3040.5	2.0	10.4	56.1
IV	17500	0.84	20807.7	1.5	767.9	3	3053.3	2.5	7.4	40.1
V	13937.5	0.71	17351.0	1.8	629.6	2	3117	3.0	5.91	36.7

Note, unit of indices following,

F1, ten thousand Yuan; F2, year ; F5, ten thousand Yuan;
F4, year; F6, % ; F7, year;
D3, ten thousand; C4, % ; C3, % ; C5, % .

Scoring for evaluating index of evary projct, we define that,

1. Quantitative index, for positive proportional index(that is the more larger value of index, the better), her maximal scoring value is 10; the mininal is 1, other is determed by ration. For negative proportional index(that is the more smaller, the more better), her mininal value is 10, the maximal is 1, other is determed by ration.

2. Qualitative index, we score for projects based on satisfactory grade of every project for this index. The satisfactory grade is the best it is scored by 10; the worst, it is 2; the better, it is 8; the good, it is 6; the bad, it is 4; if a project can fully not satisfy or violate this index , the one is scored by 0.

Based on above scoring standard, the scoring values five projects for every index are listed in table 11.

table 11, synthetic scoring of projects (I, Index; P, Project)

P \ I	F1	F2	F5	F4	F6	F7	D3	C4	C3	C5	SS
W	2	1	5	3	3	3	18	20	17	17	
I	1	1	1	1	1	10	10	1	5.8	4.9	425.9
II	8.3	5.5	8.1	9	8.1	8.9	6.4	3.3	10	1	508.8
III	10	8.4	10	10	10	4.4	5.4	5.5	6.5	4.4	544.1
IV	8.5	9.3	8.5	9	8.3	2.1	4.7	7.8	2.8	9	568.2
V	5.1	10	5.2	6	4.6	1	1	10	1	10	486

Note, 1. a weight of a project for index is found by mutiplied with 100 and changed to integer for the weight.

2. SS — syhthetic scoring

From table 11, it is showed that synthentic scoring of fourth is the maximal, therfor, one is the optimal project. This choosing result conform realitic circumstances of Dangan oilfield, and it is setisfied by various areas experts. They intent to use obtaind results from this research, optimizing exploiting projects.

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