Evaluation of Efficiency and Achievement for R&D Institutes with AHP

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Abstract

The evaluation of the efficiency and the achievement of Research and Development Institutes requires information about the institutes' management, products, economic benefits, R&D activities and so on. The actual evaluation of the R&D Institutes is done by comparing them in relative terms for a certain period of time. All R&D institutes are ordered according to their composite score to compare their efficiency and achievement. The evaluation provides us with references not only for managing R&D Institutes, but also for drawing up an economic and scientific development plan, establishing scientific policies and making governmental decisions.

1. Introduction

An R&D Institute is a complicated system. It is involved in all industries of the national economy as well as in every field of science. In the annual statistics of science and technology institutes, there are hundreds of indicators used for R&D institutes. These indicators can be classified into personal, financial, project, achievement and so on. During previous efficiency and achievement evaluations for Science & Technology Institutes [1], we usually set up an indicator system first and seek advice from experts to collect every indicator's weight value, and calculate a dimensionless indicator value according to the S&T Institutes' statistical data. Then, we calculate every institute's evaluative score. Finally, we can put all S&T institutes in order according to their composite scores. The problem is that we can obtain different orders for the same group of S&T Institutes during the same period with the same statistical data, because we

can use different indicators, and different weight values for different evaluations. Now, we set up a new method for evaluating the efficiency and the achievement for R&D Institutes on the basis of an indicator system built in which the weights of the indicators were obtained by consulting experts, and according to the principles of AHP [2]. We have evaluated technical development and agricultural sciences R&D institutes in the Jilin Province of P. R. China with this method and have obtained satisfactory results.

2. The Hierarchy for Evaluating R&D Institutes

The hierarchy of our problem consists of four levels: the goal; the analytical criteria, the indicators (18), and the objects to be evaluated - the R&D Institutes. The model is shown in Figure 1.

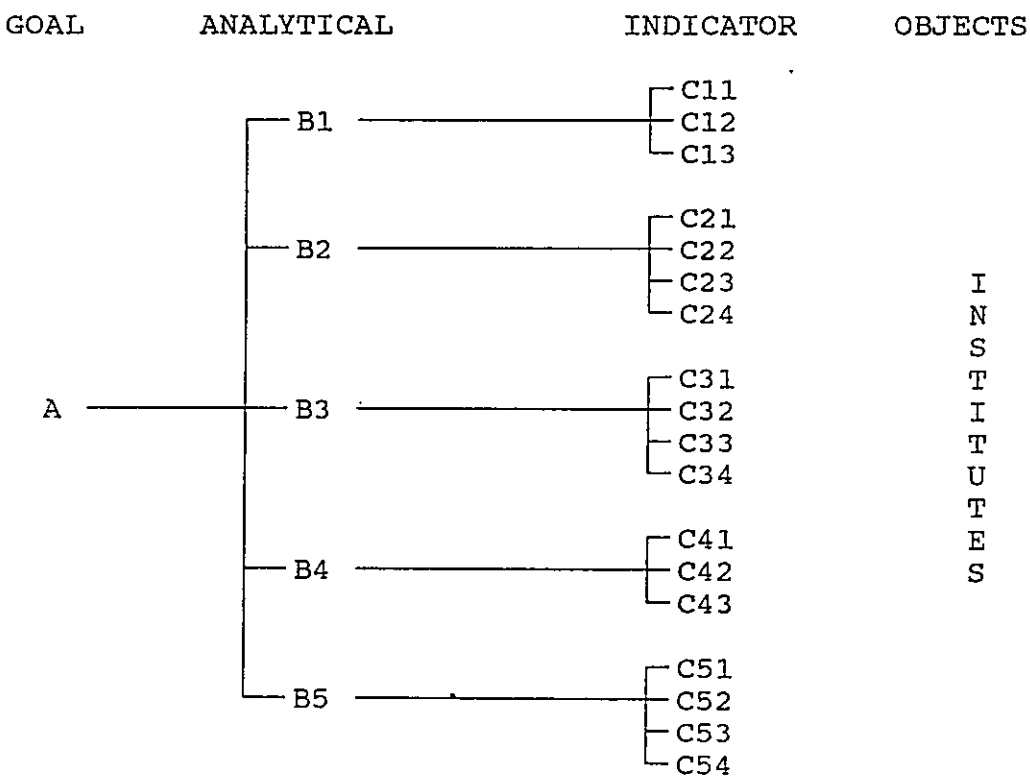

Figure 1. An AHP Model

where

A: Efficiency and achievement.

B1: Scientific research management.

C11: The proportion of the number of staff and workers engaged in S&T activities to the number of total staff and workers.

C12: Degree of expenses guaranteed for scientific research.
C12=(FI1+FI2+FI3+FI4+FI5)/FI
FI1: Institute's operating expenses.
FI2: Special project expenses.
FI3: Natural science funds.
FI4: Income comes from other institution and enterprises for entrusted project research.
FI5: Income comes from selling scientific achievements.
FI: Total annual income.

C13: Reform inside institute.
C13= (RM1+RM2+RM3+RM4)/4
RM1: Carrying out contract system of title of technical and professional post.
RM2: Carrying out contract system of leader assume responsibility or leaders assume goal responsibility during term of office.
RM3: Carrying out of contract system of scientific research responsibility or project responsibility.
RM4: Carrying out accounting system of project cost.
For every previous item, if it is carrying out, the score is 1. Otherwise, the score is 0.

B2: Efficiency of scientific research.

C21: Absorbing scientific research expenses from government per capita.
C21=(AB1+AB2+AB3)/PST
AB1: Institute's operating expenses.
AB2: Special project expenses.
AB3: Natural science funds.
PST: The number of staff and workers engaged in S&T activities.

C22: Proportion of scientists and engineers engaged in S&T activities to the total scientists and engineers.

C23: Intensity of technical developing projects.
C23=(ND1+ND2)/NP
ND1: The number of developing projects.
ND2: The number of designing and trial-producing projects.
NP: The number of total projects.
C24: The proportion of the number of projects finished to the number of total projects carried on in the year.

B3: Scientific research achievement.

C31: Score of scientific research achievement winning a prize.
C31=(5*N1+3*N2+1*N3)/PST
N1: The number of projects winning a national prize.
N2: The number of projects winning a provincial or ministerial prize.
N3: The number of projects winning a municipal prize. The number of scientific research projects winning a prize is an important reflection of S&T activities' efficiency and achievement and its material base to gain economic and social benefit.
To compute the score, we multiply the number of projects winning a national, provincial or ministerial and municipal prize separately by 5,3 and 1 because of the different levels of achievement.

C32: The number of treatises published per capita.
C32=NT/PST
NT: The number of treatises published.

C33: The number of words of S&T works published per capita.
C33=NW/PST
NW: The number of words (0000) of S&T works published. Two proportions above show the quality of staff and achievement of the institute.

C34: Index of applied project.
C34= The number of applied projects/The number of finished projects in previous two years plus this year.

B4: Economic benefit.

C41: Total economic benefit
C41= (Technical income+Non-technical income+Special project expenses+Natural sciences funds)/(Daily expenditure-Tax-Other social expenditure)

C42: Technical income per capita.
C42= (Technical income+special project expenses+S&T developing funds)/The number of staff and workers engaged in S&T activities

C43: Capability of making income.
C43= (Technical income+Non-technical income)/Total income

B5: Research and Development activities.

C51: The proportion of the number of staff and workers engaged in R&D activities to the number of staff and workers engaged in S&T activities.

C52: The proportion of the number of scientists and engineers engaged in R&D activities to the number of scientists and

engineers engaged in S&T activities.

C53: The proportion of R&D project expenses to the number of staff and workers engaged in R&D projects.

C54: The proportion of R&D projects to the number of total projects.

We constructed the judgment matrices using the 1 to 9 scale after consulting experts, and calculated the weight value and the index of consistency C.R. The results are given in Table 1:

Table 1

Judgment Matrix	Weight Value	C.R.
A--Bi	(0.1456,0.2582,0.3485,0.1351,0.1126)T	0.0352
B1--C1j	(0.5396,0.2970,0.1634)T	0.0079
B2--C2j	(0.4228,0.2656,0.1744,0.1372)T	0.0530
B3--C3j	(0.4554,0.2628,0.1409,0.1409)T	0.0038
B4--C4j	(0.4934,0.3108,0.1958)T	0.0463
B5--C5j	(0.4249,0.2701,0.1613,0.1438)T	0.0170

C.R. shows that every matrix has satisfactory consistency.

The data used for the evaluation come from the 1988 statistics of S&T Institutes of the Jilin Province [3]. First, we calculate the mean of all R&D institutes for each indicator. The every institute's indicator value is divided by the mean to get a dimensionless indicator value. We limited the indicators value as follows: if any of these non-dimension indicator values is more than 2.000, we let it equal to 2.000. Second, we multiply the indicator weight in different levels by the relative non-dimension indicator value, to obtain the analytical hierarchy evaluation value and the goal evaluation value. Then, we these values in

descending order. The larger the goal evaluation value is the better the efficiency and achievement of the institute is. The formula for the goal evaluation is given by:

$$A(t) = \sum_{i=1}^{5} B_j * \sum_{j=1}^{n} C_{ij} * Fij(t) \quad (1)$$

$$F_{ij}(t) = G_{ij}(t)/H_{ij} \quad (2)$$

where A(t) is the evaluation value of institute number t, Bi is the weight of the ith criterion, Cij is the weight of the ij indicator, Fij(t) is the dimensionless value of the ij indicator for institute number t, Gij(t) is the statistical value of the ij indicator for the institute number t, and Hij is the mean of the ij indicator number. At same time, we can write the evaluation formula of the analytical indicators as follows:

$$D_i(t) = \sum_{j=1}^{n} Cij * Fij(t) \quad (3)$$

and the formula for the weight of indicator Cij like this:

$$Eij=Bi*Cij \quad (4)$$

3. Application

We have used this method to evaluate 27 technical and agricultural sciences R&D Institutes that are subordinate to the Jilin provincial government. The results are showed in Table 2.

1. We limited the dimensionless indicator value to less than 2.000 because our evaluation is a synthetical process. We do not want to compare a single element but total efficiency and

achievement. Several dimensionless indicators whose value is more than 2.000 are C32, C33, C34 etc. These indicators mainly show apparent efficiency and achievement of recent years of work in the

Table 2

INSNM	A	A#	NONA#	B1	B1#	B2	B2#	B3	B3#	B4	B4#	B5	B5#
Water Conservancy	1.329	1	4	1.155	6	1.400	2	1.398	2	1.020	9	1.548	2
Biological	1.271	2	2	1.140	7	1.194	8	1.488	1	0.796	17	1.516	3
Metallurgical	1.173	3	8	0.974	13	0.838	19	1.324	4	1.798	2	0.982	16
EAstmeng CC	1.105	4	7	1.175	5	1.198	7	0.911	10	1.356	8	1.099	9
Academy of Agriculture	1.093	5	6	0.964	14	1.018	12	1.373	3	0.695	18	1.045	13
Traffic	1.084	6	3	1.081	10	1.153	1	0.566	13	1.837	1	0.802	22
Vegetables	1.078	7	5	0.902	20	1.251	5	1.025	8	0.540	21	1.718	1
Acad. Electro-machine	1.065	8	9	0.897	21	0.769	24	1.193	7	1.472	7	1.077	10
Ginseng	1.037	9	1	0.955	15	1.249	6	1.306	5	0.263	26	0.746	24
Sugar Beet	0.997	10	11	1.285	2	1.091	10	0.924	9	0.814	16	0.852	19
Veterinary Medicine	0.963	11	10	0.846	24	0.885	16	1.238	6	0.362	24	1.264	6
Aquatic Products	0.942	12	12	0.949	16	1.372	3	0.483	16	1.018	10	1.272	5
Computer	0.885	13	18	0.975	12	0.614	27	0.670	11	1.679	5	1.101	8
Medicine Industry	0.862	14	14	1.200	4	0.806	21	0.669	12	0.612	20	1.446	4
Grain oil	0.782	15	16	1.123	8	1.029	11	0.000	25	1.737	4	1.046	12
Plastics	0.773	16	20	0.931	17	1.098	9	0.410	17	0.890	14	0.803	21
Leather	0.770	17	15	0.887	22	1.287	4	0.282	19	0.673	19	1.063	11
Skilworm Business	0.754	18	19	1.328	1	0.845	18	0.487	15	0.315	25	1.158	7
Buiding Materials	0.741	19	17	0.855	23	0.885	17	0.282	20	1.498	6	0.774	23
Chemical Fibers	0.731	20	13	0.905	18	1.015	13	0.282	21	0.911	12	1.025	14
Bee Keeping	0.725	21	21	1.227	3	0.728	25	0.387	18	0.908	13	0.898	17
Acad. Chinese of Medicine	0.611	22	22	1.027	11	0.801	22	0.529	14	0.495	22	0.029	27
Business	0.610	23	23	0.739	26	0.793	23	0.223	22	0.929	11	0.839	20
Architecture	0.601	24	24	0.808	25	0.808	20	0.141	23	0.842	15	0.992	15
Acad. of Oil & Chemical Ind.	0.576	25	25	0.654	27	0.654	26	0.000	26	1.793	3	0.623	25
Energy Resources	0.492	26	26	1.118	9	0.894	14	0.000	27	0.000	27	0.878	18
Agricultural Machinery	0.487	27	27	0.903	19	0.892	15	0.119	24	0.372	23	0.296	26

evaluation period. If these indicator values are too large, it could affect the accuracy of the results, and we believe that if

an institute's indicator value is twice the mean of all the institutes, its work is better.

2. From table 1, we can get the analytical hierarchy indicator weights which affect the goal.

WB1=0.1456; WB2=0.2582; WB3=0.3485; WB4=0.1351; WB5=0.1126.

The indicator which affects the goal the most is B3. The indicator which affects the goal the lowest is B5. The difference between these weights is acceptable.

3. According to formula (4), we can calculate every indicator's weight affecting the goal. All weight values are listed below:

C11=0.0786; C12=0.0433; C13=0.0238;

C21=0.1092; C22=0.0686; C23=0.0450; C24=0.0354;

C31=0.1587; C32=0.0916; C33=0.0491; C34=0.0491;

C41=0.0666; C42=0.0420; C43=0.0264;

C51=0.0478; C52=0.0304; C53=0.0182; C54=0.0162.

The indicators which have the most effect on the doal are C31, C21, C32, C11. The indicators affecting the goal the least are C54, C53, C13. The difference between all weights is not very large. It indicates that the indicator system is reasonable.

4. Our method, set up on the basis of the principles of AHP can be used for evaluating efficiency and achievement for R&D institutes being subordinated to the government during different periods. While we do not think that this method is perfect, it can be improved to gain more satisfactory results.

References

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