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Comparison study on the order degree of organization structure synergy in coal mine under-well project

In order to overcome the disadvantage of the synergy shortage of the traditional functional organization structure of the coal mineÿthe projectized organization structure was set up, and the theory of information entropy was introduced for establishing the evaluation model of organization structure synergy order degree from the perspective of organization structure validity and accuracy of information transmission, then, through the calculating and comparing, it is prove that the ordering and synergy of projectized organization structure are better, and more suitable for under-well project management of coal mine.

Keywords: coal mine, under-well project, organization structure, order degree, information entropy

1. Introduction

This paper defines the under-well project of coal mine as the exploiting, tunneling, installing, backstoping and retracement around working surface. The 5 projects are the core of the coal mine value chain. And the management of producing, operating and safety in a coal mine is working around them. This process involves more than a dozen departments, and they form a complex structure system [1, 2].

The essential principle of the under-well project organization setup is the division and cooperation. The complexity of the synergic structure and the synergic operation are reflected by the relationships among system and departments and the interrelation of information transmission. Therefore, it becomes a vital issue that how to coordinate organizational structure and improve the efficiency of the departments in the synergy system.

There are 6 popular corporation structure forms in the traditional economy, which are known as the linear structure, functional structure, linear functional structure, business structure, decentralized structure, and matrix structure. It has rationality in both from the technical conditions and historical context, but may rigidify management in the longitudinal control structure. Therefore, it tends to increase the administration cost, dull the reflection of an organization, and reduce the decision quality. To solve this problem, the sufficient lateral communication and integration is indispensable.

At present, most of the coal mine adopts the functional organization structure, which means that the enterprise divides department based on the function and function similarity. Every department is responsible for its own function, and the specific project coordination is responsible for the departments' person in charge. The traditional engineering project implementation is based on the division of labor and collaboration. And the function interfaces of multi-level longitudinal organization led to many imperfections such as insignificance activities and increasing management cost, weak transverse flow control, inefficient inter-departmental communication, difficult work coordination, et.al.[3] The shortcoming of traditional functional organization structure shows that coal enterprises should base on the characteristics of coal mine production to strengthen the organizational structure of lateral communication and coordination, and build new coal mine project type organizational structure. These facilities can improve the organization coordination between various departments and ensure the smooth implementation of the projects.

2. Methods

2.1 Concept of information entropy

In 1856, German physicist Clausius first introduced the concept of entropy in the On the Moving Force of Heat. He used the entropy to measure the failure in a physical system of energy [4,5]. Founded in 1948, Shannon provided the information theory, he defined information as the quantity of the uncertainty that a process of communication to eliminate, and the information entropy is defined as the uncertainty sources in the process of communication signal. He also provided the and the formula to calculate the information entropy. The formula makes the quantitative description becomes possible [6].

Information entropy is the measurement of uncertainty. The greater the information entropy is, the greater the uncertainty of information it reflected, and its utility value is smaller. Conversely, the smaller the information entropy

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represents the smaller the uncertainty and the greater the utility value of information. The information entropy has been widely used in almost all disciplines, in the field of natural science, social science and management science application is becoming mature.

2.2 The information entropy model

It assumes that the discrete random variable X has n possible values (x_1, x_2, …, x_n), and the probability of every value are (p_1, p_2, …, p_n). Then, the entropy is defined as the $E(X) = -\sum_{i=1}^{n} p_i lbp_i$. And in this formula, $P_i \geq 0$, $\sum_{i=1}^{n} p_i = 1$, $lb\sum_{i=1}^{n} p_i = 0$. X represents a system, x_i and p_i (i = 1, 2, …, n) respectively represents that the n possible status and the incidence of every state in this system, then $E(X)$ is a system of information entropy of X, which describe the amount of information needed for describing system X. $E(X)$ describe the uncertainty of the system X. The larger information entropy reflects the greater the uncertainty of a system.

3. Results

In order to overcome that the traditional functional organization structure shortages of synergy, this paper relies on coal mine of Kailuan group co-ordinated management practices to build the coal mine project type organizational structure, and introduce the concept of information entropy. Due to the perspective of organizational structure validity and accuracy of information transmission, this paper established a coal mine project management organization structure information entropy evaluation model. After calculating and comparing, the project type organizational structure is more suitable for the coal mine project management.

4. Discussion

4.1 Coal mine under-well project organization structure synergy ordered degree evaluation model

The construction of organization structure and management usually focuses on the order of the organization state. The effectiveness of information communication is the fundamental guarantee to improve organized order. The entropy of different organizations is diversity, and the effectiveness of the circulation of the information can use information entropy quantitatively described in a particular organization to indicate the organization macroscopic degree of order[7,8]. In information theory, the time effectiveness and accuracy are two important indexes in the process of information transfer, and the organizational structure time effectiveness and system structure synergy degree of order are used for the organizational structure evaluation model.

4.1.1 Hypotheses

Model is an abstraction of practical issue, and its establishment should under certain conditions.

1. Number of members in the organization structure remains the same, and as the management range falls, the organization degree rises.
2. The information in the organization structure is flowing layer-by-layer, and the information cannot flow over one degree.
3. The total amount of information quantity in the organization structure remains the same.

4.1.2 Definition of the parameters

We assume that organizational structure has k management levels and n items (Fig.1). The straight line means the direct information flow between superior and subordinate. (1) reflects the first item in the organizational structure and the (n) is the n^{th} element.

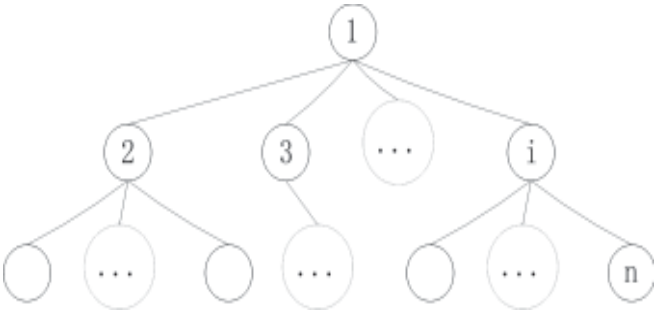

Fig.1 System organization structure

Definition

L – Contact length: connection number passing between two nodes of organization structure.

S – Contact span: The number of nodes which have a direct link with one node in organization structure.

R_1 – The time effectiveness of organization structure: Information flow speed in the transmission between each node in organization structure.

R_2 – The quality of organizational structure: Information flow accuracy in the transmission between each node in organization structure.

H_1 – Time effectiveness entropy of organizational structure: Measurement of the uncertainty to information circulation time effectiveness between each node in organization structure.

H_2 – Quality entropy of organizational structure: Measurement of the uncertainty to information circulation quality between each node in organization structure.

A – Microscopic state of organizational structure: The number of some elements when observed organizational structure from certain aspect.

P – Microscopic state probability of organizational structure: The ratio between the microscopic state number of a node and the sum of all nodes.

TABLE 1 CALCULATION STEPS OF ORGANIZATION STRUCTURE'S AGING AND QUALITY

	Calculation step of organization structure time effectiveness	Calculation step of organization structure quality
1	Calculate the minimum contact length of nodes: L_{ij}	Ensure the contact span of nodes: S_{ij}
2	Calculate the total time effectiveness of organization structure: $A_1 = \sum_i \sum_j L_{ij}$	Calculate the total microscopic state of organizational structure: $A_2 = \sum_{i=1}^{n} S_{ij}$
3	Calculate the time effectiveness microscopic state probability of organizational structure: $P(i,j) = \frac{L_{ij}}{A_1}$	Calculate the quality microscopic state probability of organizational structure: $P(i) = \frac{S_{ij}}{A_2}$
4	Calculate the time effectiveness entropy between two nodes in the organizational structure: $H_1(i,j) = -P(i,j)\log_2 P(i,j)$	Calculate the quality entropy of nodes in the organizational structure: $H_2(i) = -P(i)\log_2 P(i)$
5	Calculate the total time effectiveness entropy of organizational structure: $H_1 = \sum_{i=1}^{n} \sum_{j=1}^{n} H_1(i,j)$	Calculate the total quality entropy of organizational structure: $H_2 = \sum_{i=1}^{n} H_2(i)$
6	Calculate the maximum time effectiveness entropy of organizational structure: $H_{1\max} = \log_2 A_1$	Calculate the maximum entropy of organizational structure: $H_{2\max} = \log_2 A_2$
7	Calculate the organization structure time effectiveness: $R_1 = 1 - \frac{H_1}{H_{1\max}}$	Calculate the organization structure quality: $H_2 = \sum_{i=1}^{n} H_2(i)$

4.1.3 Calculation step of organization structure time effectiveness and quality

Organizational structure time effectiveness is the speed of information circulation in the organizational structure [9]. And the organizational structure quality is the veracity degree of the information circulation in the organizational structure.

4.1.4 Organization structure order degree

This paper used the time effectiveness and quality of information in the organization structure to establish the model of organization structure entropy, and used this model to measure the validity of system organization structure. The validity of organization structure are reflect by *R*, large *R* value means the high order and efficiency [10].

$R = \alpha_1 R_1 + \alpha_2 R_2$

R_1 – organization structure time effectiveness; R_2- organization structure quality

$\alpha_1 + \alpha_2 = 1$

α_1 : the weight of organization structure time effectiveness

α_2 : the weight of organization structure quality

4.2 COAL MINE UNDER-WELL PROJECT ORGANIZATIONAL STRUCTURE

4.2.1 traditional coal mine under-well project functional organization structure

The coal mine projects (exploiting, tunneling, installing, backstoping and retracement) are the core of the value chain of coal mine. Coal mine production management, operation management, security management, and other work are carried out around them. Therefore, the coal mine project life cycle process covers production, oprating, security, electromechanics and technology, and the specialized departments are more than a dozen. Based on the definition of the coal mine under-well project construction and management process, the under-well project organization structure can be establised as Fig.2.

Based on the nature and functions of related units in the coal mine under-well project, the coal mine under-well project units can be divided into three categories, which are management unit, production unit and auxiliary units. The main function of every unit in the process of the coal mine project management is shown in Table 2.

4.2.2 Projectized organizational structure of coal mine under-well project

In order to guarantee the successful implement of the coal mine project management, this paper was based on the matrix organization structure and the actual production in coal mine to design the coal mine projectized organizational structure. (Fig.3)

The main features of coal mine under-well project organization structure are shown as follow:

(1) Set up a project management office

Set up the project management office (PMO) in the organizational structure who directly responsible to the general manager, is responsible for the whole coal mine underground engineering project management. Give priority to support functions. General functions of the PMO including the development functions, control functions, operating functions and supporting functions, mainly to provide

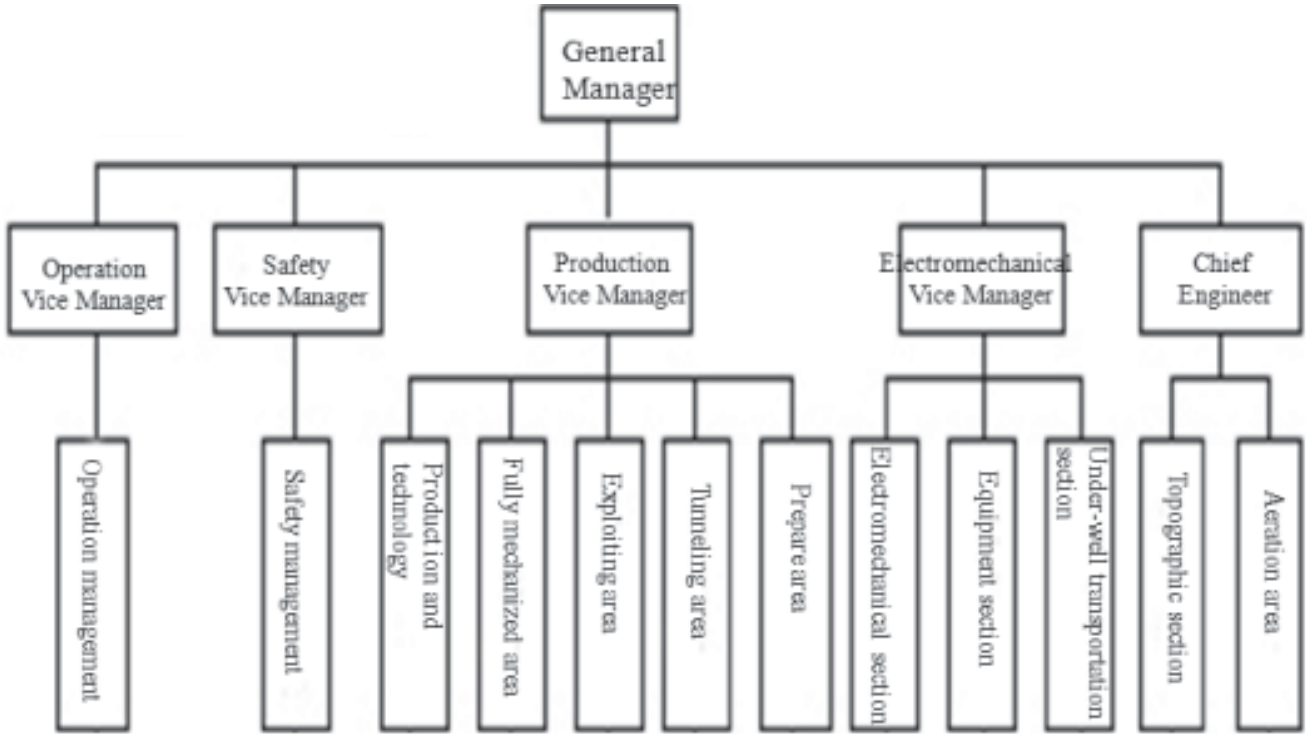

Fig.2 Organization structure of coal mine under-well project management

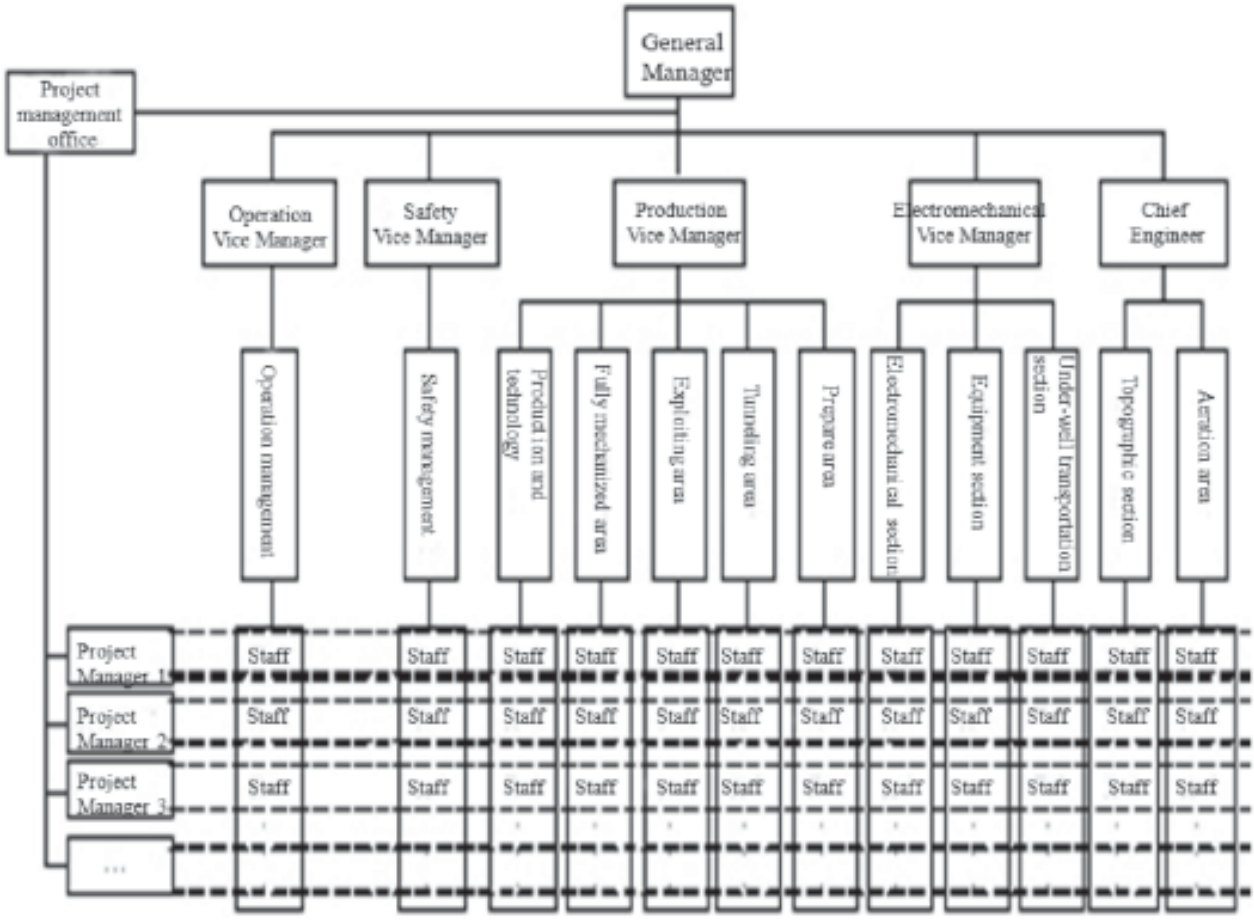

Fig.3 Projectized organizational structure of coal mine under-well project

Table 2 Department functions of coal mine under-well project organization structure

Production Unit	Fully mechanized area	Mining engineering construction and management
	Exploiting area	Develop project construction and management
	Tunneling area	Tunneling engineering construction and management
	Prepare area	Mining engineering construction and management, withdraw
Supplementary Unit	Electromechanical section	Engineering equipment installation, demolition and reconstruction, operation and daily management and maintenance
	Equipment section	Engineering equipment planning, allocation, construction and inspection appraisal
	Under-well transportationsection	Engineering transport system installation, operation, maintenance and maintenance
	Topographic section	Engineering geology, hydrology, measurement, drilling, and other technical data
	Aeration area	Anti-corrosion engineering on the construction of the system and accessory equipment, daily management and maintenance, the index inspection management

management support for the project management, administrative support, training, consulting, technology services, knowledge management, and other support services, enhance the overall success of the project management. In this case, the PMO work as auxiliary, make less impact on the organization, which is easier to functions by members of the organization. [11,12]

(2) Set up the project manager

The project manager is mainly responsible for project synergy work, and it is chosen by the project management office according to the project bidding. The project manager is not only a manager, but a project interface. Integrator, usually token by the construction unit team leader, is responsible for project coordination of relevant departments and between members, undertake interface management, at the same time finish the plan tasks .

(3) Carry out the project bidding

Making each team a project team through mining project bidding, take each working face mining as a project. Through the competition to mobilize the enthusiasm of each team, project team can also promoted the shift of the technology and method innovation.

(4) Team management

All the team members of coal mine engineering project need to withdraw from the various functional departments, the project team has the characteristics of temporary, specialization, complementary, unified command, efficiency, symmetry in liability. Basic unit need to build a project team, project director's potency to choose the project manager ,management and move people should be strengthen, realize symmetry in liability. Project members performance directly linked to the project, examine by the project manager, effectively arouse the enthusiasm of the members, ensure the project oriented to achieve organizational goals.

4.3 Measurement of the order degree for organization structure synergy in coal mine under-well project

4.3.1 Measurement of the order degree for functional organization structure

The traditional coal enterprises coal mine project organization structure is the functional organization structure. In order to convenient for explain, this paper exchanged the coal mine under-well project functional organization chart into a tree structure (Fig.4). ○ is used for expressing the department and vice managers, and numbered there number. – reflects the leadership and relationship between supervisor and departments.

Then, this paper used structure entropy to measure the order of under-well project functional organization structure.

Table 3 Time effectiveness calculation of functional organization structure

L_{ij}	$P_1(i,j)$	$H_1(i,j)$	Contact sign	Total	Microscopic state
1	1/69	0.0885	1-2 ⋯ 6, 2-7, 3-8, 4-10 ⋯ 13, 5-14 ⋯ 16, 6-17, 6-18	17	17
2	2/69	0.1481	1-7⋯18, 2-3 ⋯ 6, 3-4 ⋯ 6, 4-5, 4-6, 5-6, 9-10 ⋯ 13, 10-11 ⋯ 13, 11-12, 11-13, 12-13, 14-15, 14-16, 15-16, 17-18	26	52
Total	1				69

(1) Time effectiveness calculation of functional organization structure (Table 3)

Total time effectiveness entropy: H_1 = 5.3551;

H_{1m} = 6.1085; Time effectiveness: R_1 = 0.1233

(2) Quality calculation of functional organization structure (Table 4)

TABLE 4 QUALITY CALCULATION OF FUNCTIONAL ORGANIZATION STRUCTURE

S_k	$P_2(i,j)$	$H_2(t)$	Contact sign	Total	Microscopic state
1	1/17	0.2404	2,3	2	2
2	2/17	0.3632	6	1	2
3	3/17	0.4416	5	1	3
5	5/17	0.5193	1,4	2	10
Total	1				17

Total time effectiveness entropy: H_2=3.3242;

Maximum quality entropy: H_{2m} =4.0873;

Quality: R_2 =0.1867

(3) Degree of order of functional organization structure

$R = (R_1+R_2) / 2 = (0.1233+0.1867) / 2 = 0.155$

4.3.2 Measurement of the order degree for projectized organization structure

The coal mine project projectized organization structure is shown as Fig.3. In order to convenient for explain, this paper exchanged the coal mine under-well project projectized organization chart into a tree structure (Fig.5). In the foundation of Fig.4, (19) is used for expressing the project management offices. – reflects the relationship between the management office and other processes.

Then, this paper used structure entropy to measure the order of under-well project projectized organization structure.

(1) Time effectiveness calculation of projectized organization structure (Table 5)

Total time effectiveness entropy: H_1 = 7.0176;

Maximum quality entropy: H_{1m}= 7.8948; Time

Fig.4 Functional organization structure tree diagram of coal mine under-well project

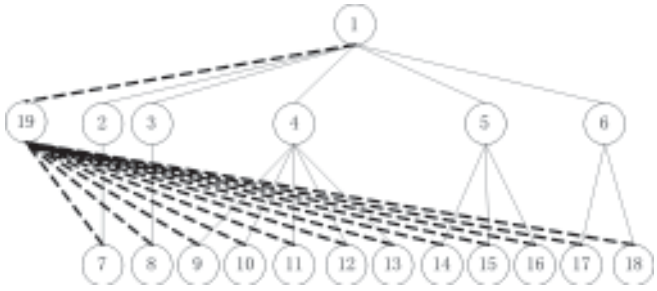

Fig.5 Projectized organization structure tree diagram of coal mine under-well project

Effectiveness: R_1 = 0.1111

(2) Quality calculation of projectized organization structure (Table 6)

Total time effectiveness entropy: H_2=2.0884; Maximum quality entropy: H_{2m}=4.9069;

Quality: R_2=0.5744

(3) Degree of order of projectized organization structure

R=ÿR_1+R_2ÿ/2=ÿ0.1111+0.5744 ÿ/2=0.343

4.3.3 Analysis of the synergy degree of order

According to the figure in Table 7, under the same time effectiveness and quality weights, the functional organization structure has time effectiveness of 0.1233 and the quality of 0.1867, while the projectized organization structure has time effectiveness of 0.1111 and quality of 0.5744. The results means that: the time effectiveness of projectized organization structure has a little lower time effectiveness than functional

TABLE 5 TIME EFFECTIVENESS CALCULATION OF PROJECTIZED ORGANIZATION STRUCTURE

L_{ij}	$P_1(i,j)$	$H_1(i,j)$	Contact sign	Total	Microscopic state
1	1/238	0.0332	1-2⋯6, 1-19, 2-7, 3-8, 4-10 ⋯ 13, 5-14 ⋯ 16, 6-17, 6-18, 19-7 ⋯ 18	30	30
2	2/238	0.0579	1-7⋯18, 2-3⋯6, 3-4⋯6, 4-5, 4-6, 5-6, 9-10⋯13, 10-11⋯13, 11-12, 11-13, 12-13, 14-15, 14-16, 15-16, 17-18 19-2⋯6, 1-19-7⋯18, 7-19-8⋯18, 8-19-9⋯18, 9-19-10⋯18, 10-19-11⋯18, 11-19-12⋯18, 12-19-13⋯18, 13-19-14⋯18, 14-19-15⋯18, 15-19-16⋯18, 16-19-17⋯18, 17-19-18,	104	208
Total	1				238

Table 6 Quality calculation of projectized organization structure

S_k	$P_2(i,j)$	H_2 (t)	Contact sign	Total	Microscopic state
1	1/30	0.1636	2, 3	2	2
2	2/30	0.0784	6	1	2
3	3/30	0.3322	5	1	3
5	5/30	0.4308	4	1	5
6	6/30	0.4644	1	1	6
12	12/30	0.5288	19	1	12
Total	1				30

Table 7 Order degree comparison between functional and projectized organization structure

	Time effectiveness	Quality	Validity
Fundamental organization	0.1233	0.1867	0.1550
Projectzed organization	0.1111	0.5744	0.3428

one, and the speed of information transfer is lower than functional one; the quality of projectized organization structure is obviously higher than functional one, and the veracity of transferring information is obviously higher than the functional one.

The order of functional organization is 0.1550, while the projectized is 0.3428. Comparing with two structure, the projectized one is better.

The analyses above based that the organizational time effectiveness and quality weight both are 0.5. If the weight change, the order of organization is changed and the results will be different.

5. Conclusion

The traditional coal mine management theories are usually based on the highly division and specialization, emphasis on the importance of division of labor and less attention to the whole. The coal mine under-well projectized organization management focuses on the effect of project leader, team co-operation, and synergy of departments. Then, the structure has higher flexibility than traditional one and more suitable for the feature of under-well production.

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