Optimization of Management Structure Based on Information Theory

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Abstract. Information process is the basic function of the management structure, and the management structure can affect benefit and competition of the enterprise largely. Taking the information theory as a tool, and using the qualitative and quantitative methods to analysis overall efficiency and the speed of the market response of the enterprise under the function and matrix management structure. At the end, calculate and disuss a sample to verify the model. The conclusion indicate that the enterprise overall efficiency is the highest under the functional structure, and the speed of response of the market is the quickest under the matrix structure. Therefore, it's necessary to tradeoff between the overall efficiency and the speed of the market response when the enterprise design or adjust management structure.

Keywords: Information theory, Management structure, Overall efficiency, Market respond time.

1   Introduction

Management structure is the outcome of the divide the work, department develop, control span, and authorization. At the same time, organizational structure is the organic combinine of structure and authority, it has great influence on productivity and manage benefit.

Contingency Theory consider that a unified, best management structure is impossible, which should be continued adjusted according to changing condition. In their opinions, the affect factors not only the conditions, but also include the goal, size of the organization, and competition. The schoolars of Contingency, Porter and Lawler consider that compare to the hierarchy structure, the flat structure inexistence obvious and overall advantage.

At present, there are some qualitative methods and conclusions, but quantitative methods still scarcity. Csaszar, F. A. explores the relationship between organizational structure and exploration and exploitation[1]. Droge et al. discuss how to reduce environment uncertainty and which organizational structure should be adopted[2]. Tolliver researched on the organization reengineer under uncertainty[3]. Radner assume that processing information takes valuable time, Delay reduction can be traded off against the cost of more "processors"[4]. Raviv indicate that firms that do not face tight resource

constraints, highly regulated firms, and firms in stable environments will tend to have decentralized organizational structures. The optimal design of the organization trades off the costs and benefits of various configurations of managers[5]. Cristiano M. Costa et al. model the tradeoff between the balance and the strength of incentives implicit in the choice between hierarchical and matrix organizational structures [6]. In Chinese, Song et al. use entropy theory analysis manage efficiency from information transfer, fuction and structure complex[7].

This paper use information theory to analysis the information content, which processed by each hierarchy in the enterprise. When enterprise produce several products at the same time, the total information content processed by enterprise indicate the overall efficiency, the information content processed to complete single product or project indicate the speed of the market response. It's necessary to tradeoff between the overall efficiency and the speed of the market response when the enterprise design or adjust the management structure. Enterprise should adopt corresponding management structure according to strategy and market condition. At the end, through calculate a real enterprise as example to verify the theoy model.

2   Model Assumptions

In Shannon's opinion, information is "difference of two uncertainty". Information content is amount of uncertainty reduce or eliminate, so it equals to negative entropy. Both Shannon and Weiner had given the mathematic equation of information content:

$$H(x) = -\sum_{i=1}^{n} p(x_i) \log_a p(x_i) \tag{1}$$

$H(x)$ denote the information content of event collection of x, $x_1, x_2, \ldots, x_n$ denote the possible state, the probability of x_i state is $p(x_i)$. The bottom of logarithm is 2 in this paper, then the unit of information content is bit.

For facility to use information theory analysis management structure, we have the following two assumptions:

Assumption1: Any agent faces the same information content of each subordinate. So if a agent has n subordinates, the information content of each subordinate is $-\frac{1}{n}\log_2 \frac{1}{n}$.

Assumption2: All the products or projects in enterprise have the same information content. So if the enterprise has k products or projects at the same time, and when a agent has n subordinates, the information content of each subordinate is $-\frac{1}{kn}\log_2 \frac{1}{kn}$.

For a given management structure, the more information content need to process, the more time and cost consumed. So the size of information content can regard as criterion to measure the overall efficiency and the speed of the market response of enterprise. Then, we have the fllowing two propositions:

Proposition 1: When the enterprise has k products or projects at the same time, the smaller the total information content processed by enterprise, the higher the overall efficieny.

Proposition 2: The smaller the total information content processed to complete single product or project, the faster the speed of the market response.

3   Function Management Structure

Under the function management structure, the goal is interior efficieny and special technique. The advantage of fucntion management structure is easy to get scale economic, but disadvantage is the speed of the market response is slow. Assume enterprise has n fuctional departments, each departmet has m_i subordinates, $i=1,2,\ldots,n$, engage in k products or projects. The diagram of fuction organizational structure depicted in Figure 1.
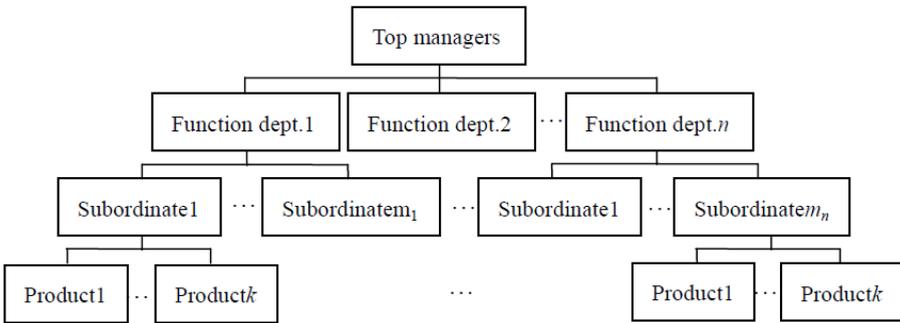

Fig. 1. Function organizational structure

Under fuctional structure, top managers are unified distribution resource for all the products or projects. According to assumptions, the information content processed by top managers is

$$H_1 = -\sum_{i=1}^{n} \frac{1}{kn} \log_2 \frac{1}{kn} \tag{2}$$

By the same methods, the information content processed by fuctional departments is

$$H_2 = -\sum_{i=1}^{n} \sum_{j=1}^{m_i} \frac{1}{km_j} \log_2 \frac{1}{km_j} \tag{3}$$

The total information content processed by enterprise is

$$H = H_1 + H_2 = -\sum_{i=1}^{n} (\frac{1}{kn} \log_2 \frac{1}{kn} + \sum_{j=1}^{m_i} \frac{1}{km_j} \log_2 \frac{1}{km_j}) \tag{4}$$

For all the products or projects are unified completed, so the information content processed to complete the single project is equal to the total information content processed by enterprise.

$$h = H_1 + H_2 = -\sum_{i=1}^{n}(\frac{1}{kn}\log_2\frac{1}{kn} + \sum_{j=1}^{m_i}\frac{1}{km_j}\log_2\frac{1}{km_j}) \tag{5}$$

4   Matrix Management Structure

The matrix management structure has a great advantage due to its flexibility of use; it can coordinate the task setting requirements, and devote itself to achieving a specific goal.

The faster the response of the market is, the better an adaptation to a highly competitive market. But as a result of the redundancy in resources configuration, multiple leadership factors, the enterprise sees a tremendous increase in cost, and as a consequence an overall deficiency will affect its working environment.

Under matrix management structure, function departments need to allocate independent staff and resources, which helpful to complete the project. The diagram of matrix management structure depicted in **Figure 2**.
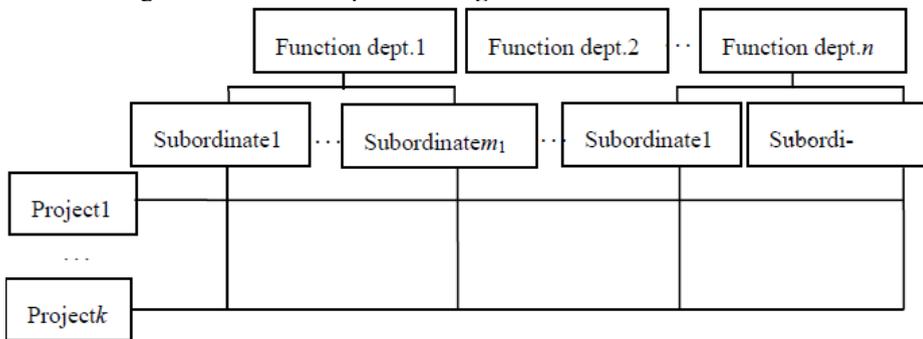

Fig. 2. Matrix management structure

To complete the given project, project management team(PMT) need to communicate with n function departments, the information content processed by PMT for each project is

$$H_{1l} = -\sum_{i=1}^{n}\frac{1}{n}\log_2\frac{1}{n}, \; l=1,2,\ldots,k \tag{6}$$

The information content processed by function departments for each project is

$$H_{2l} = -\sum_{i=1}^{n}\frac{1}{m_i}\log_2\frac{1}{m_i}, \; l=1,2,\ldots,k \tag{7}$$

Then, total information content processed by enterprise is

$$H = \sum_{l=1}^{k}(H_{1l} + H_{2l}) = -\sum_{l=1}^{k}\sum_{i=1}^{n}(\frac{1}{n}\log_2\frac{1}{n} + \sum_{i=1}^{m_i}\frac{1}{m_i}\log_2\frac{1}{m_i}) \tag{8}$$

The information content processed to complete single project is

$$h = H_{1l} + H_{2l} = -\sum_{i=1}^{n}(\frac{1}{n}\log_2\frac{1}{n} + \sum_{j=1}^{m_i}\frac{1}{m_j}\log_2\frac{1}{m_j}) \tag{9}$$

So, through calculate the total information content processed by enterprise to complete all products and to complete single project, we can get the overall efficiency and the speed of the market resopnse of the enterprise under different management structures.

5   Sample and Discuss

Here is a manufacture enterprise we choice to analyse, The main products of the enterprise are transportation facility. To simplify the analysis, we exclude some irrelative departments, such as human resource department.

Apply the information content model to calculate the overall efficiency and market respond under the fuction and matrix management structure. The number of departments $n=6$; the number of subordinates of each department $m_1=2$, $m_2=3$, $m_3=2$, $m_4=2$, $m_5=3$, $m_6=3$; the number of products $k=3$. We can get the Table 1 through calculate.

Table 1. The information content under different management structures(unit: bit)

Organizational structure	Overall efficieny	Market response
Function	21.43	21.43
matrix	31.02	10.34

From the above computed result we can see that, when the function management structure is built as a unified distribution resource, all products or the project complete, the content of processed information total is least, that the enterprise overall efficiency is the highest. A single product or the project completion time processes the most information content, and the speed of the market response is the slowest.

In the matrix management structure, because of the "Dual lead", the processing of information content is huge, and the enterprise overall efficiency is the lowest; But it is possible to fully transfer the resources to a single product or project for completion. The single product or project processes information with the least content, thus the speed of response of the market is the quickest.

The enterprise should adopt what type the management structure pattern to be able to decide how to determine an overall efficiency and a measurement of the speed of the market response. If the market conditions change rapidly, the competition becomes fierce, then the enterprise's strategy would be to develop a new market, or acquire a good prestige for survival, therefore the enterprise should adopt the matrix management structure, in order to speed up its own market response; but reduces the enterprise the overall efficiency to take the price; If market conditions become stable, the enter-

prise's market share is high, the enterprise should then adopt a lower cost strategy and try to increase profits. When strategy and market situation become interrelated factors upon which strategy must be adopted, then the mixed type management structure can be considered.

6   Conclusion

Changes are more than obvious, and the management structure is not some kind of its existence and the characteristic is not restrained. So, the management structure depending on the enterprise's strategy and market conditions.

The enterprise's overall efficiency is the highest under the function management structure, the speed of response of the market is the quickest under the matrix management structure. So, the enterprise need to tradeoff between the overall efficiency and response of the market when design or adjust the management structure.

This conclusion is based on a suitable hypothesis, taking information theory as the tool, and using the method analysis which is qualitative and the quota uniformity. Certainly, the enterprise management structure design is an item of complex systems engineering, many other aspects should be considered because of their influence on factors such as, the enterprise size, the enterprise culture and so on, needing to carry on a further exploration and the research.

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