The Efficiencies of Organizations and their Impact on Complexity

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Abstract
The inefficiency or complexity of organizations can be seen as two sides of the same coin. There appears to be a methodology for assessing these parameters which could support arguments for limiting the sizes of groups devoted to such issues as high tech development projects, sales activities, logistics efforts, etc. The use of a quantitative method to gauge complexity and efficiency in the activity of an organization could also help support decision making, and scale the management of business efforts. A different type of vector is introduced here, one that targets the individual elements of the group being analyzed using work activities. Other researchers have pursued deterministic models to analyze organizational efficiency, but a method is presented here which can provide an analytical solution to such problems. (1) Complexity has been linked to many corporate challenges, such as change, chaos (non-linear behavior), duplication of efforts, project management problems, etc. The overall challenge in this regard is to simplify organizations as much as possible which, in itself, may be a very cost-effective way of reducing waste while improving company activity.

Linking Variables

We have all heard of the Theory of Chaos, Bayesian Inference, Monte Carlo Techniques, and other forms of future prediction. These and other math-oriented methodologies have been used over the years in helping to further our understanding of management. Everyone inherently knows, for example, that the smaller the organization, the more "efficient" it is likely to be, although this is not an absolute certainty. Even large high tech companies in the Silicon Valley eventually divide up into business groups, divisions, etc. in order to maintain some sort of reasonable efficiency.

The larger an organization grows, the more likely it is to become inefficient and complex, due to the growing number of interfaces for each element. (4) Many large organizations have betrayed their inefficiency by overlooking obvious axioms of business. For example, just over a year ago J.C. Penny was shown to be seriously understocked which led stock market analysts to question whether the company would survive.(2) Anyone knows that to thrive as a retail business, a company has to stock its shelves. Possibly, complexity led to this problem.

While it is easy to criticize large, amorphous organizations as being unwieldy, sometimes they serve a purpose, such as, being a vehicle for sharing information. (5) In other situations, especially research, it is difficult to provide an environment of efficiency, and simplicity because of the demands of the projects themselves which often draws efforts in uncertain directions. (6)

Communications within an Organization

But, what does "efficient" really mean? According to Dictionary.com, it means, "performing or functioning in the best possible manner with the least waste of time and effort". Let's apply this definition to organizations, and see if a little added math can help us judge the relative efficiencies of different-sized organizations.

Some years ago, a book called The World of Engineering, edited by John Whinnery was published. (3) It was a book ahead of its time, because it discussed, among other things, communications and the size of working groups. Dr. M.P. O'Brien had a distinguished career at Berkeley, Purdue, and MIT, but he was, like a lot of engineers, interested in trying to inject some scientific and engineering discipline into management. In his assigned chapter, he cited work done by Dr. Richard Raymond at General Electric who was trying to understand how the size of an organization could affect its efficiencies or inefficiencies if you like. The idea in any organization is to communicate – to communicate about development projects, administration, marketing and sales, logistics, company decision making, etc. Communications can make a company more or less efficient depending on how they are handled, but there is more to it than that. Communications can also affect the size of an organization, and by extension, its efficiencies.

There is one more relationship that should be framed, and that is how efficiency can affect complexity. If strong and timely communications are important to market capture and revenue growth, then communications also defines efficiency. Efficiency, or a decrease in same, also affects the apparent complexity of organizations. Thus, complexity is closely associated with communications and efficiency.

Dr. Raymond derived some interesting formulations which will be explored here. The explanation goes something like this. The work output of a group is a function of several factors. As the group gets larger, the output decreases due to these factors. These factors, include the rate at which a person works (usually normalized to one), the number of people/organizations with whom a person interacts, the types of work a person does, etc. It turns out that as a group grows, that unit becomes more and more inefficient in terms of communications interfaces due to the increasing interactions required among the various elements of the group. Dr. Raymond also considered another vital issue for determining group efficiency, and that is the ratio of communicating the details of an activity that was performed versus the actual act of doing it. Communicating the details of an activity can be appreciated when we write emails, text someone, prepare presentations, write reports, etc. Ideas and activities related in after-the-fact descriptions can be done much more rapidly than the actual activity.

Using this methodology, organizational structures can be analyzed to determine how the number of interacting elements might hinder the efficiencies of the operations of a group. The examples discussed here could be analogous to a start-up, a small company, or a franchise operation. The same approach could, however, be applied to a very large corporation, such as Cisco, E-Bay, Google, Amazon, Intel, etc. Only three sizes of

organizations are discussed here which are organizations with four, six, and eight elements per organization.

The basic equation derived by Dr. Raymond is given below with explanation.

$$W/_T = Nab / (b + 2a (N - 1))$$

Where:
W=work produced in time T; T could be an hour, day, week, etc.
a=working rate, usually taken to be 1 (one);
b=talking, writing, listening, or reading rate, i.e., the feedback rate as a multiple of the working rate; thus, if we take our working rate, and normalize it as one, then we might estimate our rate of describing what we have done as much higher, such as 16 times that of the actual work performed
N=number of workers in the group; this could also be the number of elements (sub-groups) in an organization to simplify the understanding of what is happening
T=time allocated to the total work effort

It could be argued that just the differentiation of the organization itself (multiplicity of the elements involved whether individuals or departments) is enough to drag down the efficiency of an operation by increasing its complexity. The variable "a" is the actual activity, or set of activities, performed during a typical day. For example, if someone were to participate in a staff meeting, several conference calls, a video seminar, give a presentation, work on a research project, etc. – all of these activities are performed at a "normal rate". The variable "b" on the other hand is a sort of playback function. If, during the day or at the end of the day, we sit back and relate to someone what we did that day in detail, it would take us a lot less time than what it took to actually do it. The variable "b" is also a factor for coordinating activities with others, finding out what their progress was, and what their plans are. The other variables, W, N, and T are straight forward in understanding.

Examples

Now we can look at the three organizations of sizes 4, 6 and 8. First, what is an element? We might think of an element as a department, initially. Each element interacts with other elements, and the communications interchange increases with each additional element added. So, if we have three organizations, our first inclination is to assume that the 8-element group is twice as complex as the 4-element group, and that the 6-element group is 50 percent more complex than the 4-element group.

These initial impressions could be shown to be incorrect. Efficiency, as mentioned above is defined here as being the inverse of complexity. The question is, "Can we use some sort of criteria to determine just how complex these different organizations really are?" Maybe we can. Galileo taught us about the Square-Cube Law, and from it we know that the area and volume of any object is determined by its dimensions, the length and width

for area, and the length, width, and height for volume. (7) So, it would seem logical to suppose that the complexity of an organization is based on more involved parameters than just the number of elements involved. In other words, the increasing complexity of an organization is not just a linear process.

Using the above equation, we can derive some degree of complexity as a group gets larger. The equation is modified to recognize the fact that feedback to information or instructions is usually a lot more rapid than the initial sets of information or instructions issued. Thus, if someone has feedback, objections, or suggestions for communications, that feedback will come very quickly rather than later, and will be in a more summary form. If we look at the 4-element project, its efficiency as defined by the stated formula is 2.9 which is about 72.5% of its original activity. We can even derive a complexity factor for the group which would be to take the efficiency of each element and multiply it by the number of elements involved which in this case is 11.6. We can do this because each element is reduced to its useful efficiency, and we multiple all elements together, because each element is acting independently (or nearly so) in executing its activities.

W/T = Nab / (b + 2a (N-1))
W/T = 4 * 1 * 16 / (16 + 2*1 (4-1))
W/T = 64 / 22 = 2.9 (efficiency)
Effectiveness = 2.9 / 4 = 72.5%
Complexity = 2.9 x 4 = 11.6

In summary, the efficiency of an activity is a fraction of the original which, in turn, yields an effectiveness of only 72.5% roughly. On the other hand, the complexity of the activity would be its efficiency multiplied by the number of elements for that activity.

The three group sizes have been analyzed using the same parameters, and the results are shown below:

The 4 component project has an efficiency of 2.9 or a total complexity of 11.6 (4 x 2.9)
The 6 component project has an efficiency of 3.7 or a total complexity of 22.2
The 8 component project has an efficiency of 4.3 or a total complexity of 34.4

We see now that, as the activity grows, the more complex a group becomes, the more inefficient it becomes as defined by its overall effectiveness, but not at a linear rate. Thus, the manager can now look at the three projects with better knowledge of what is going on. The 8-component project is actually about 3 times as complex as the 4-component project because of the complexity factors calculated, not twice as complex based on the number of components. The 6-component project is twice as complex as the 4-component project, not just 50% more complex, as one would think, given the number of components involved.

Implications

Armed with this information, a manager might want to make plans to enhance the communications capabilities of his/her organization as it increases in size by increasing certain features in a research group, such as instant messaging (IM), or texting, at the expense of relying on email, or presentations.

More to the point, however, a manager might also consider rearranging an organization's structure in favor or smaller groups, with simpler interfaces in order to hold down complexities while aiming at greater efficiency of operation.

Citations

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