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Organizational Complexity

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1. Overview

Organizational complexity is defined as the amount of differentiation that exists within different elements constituting the organization. This is often operationalized as the number of different professional specializations that exist within the organization. For example, a school would be considered a less complex organization than a hospital, since a hospital requires a large diversity of professional specialties in order to function. Organizational complexity can also be observed via differentiation in structure, authority and locus of control, and attributes of personnel, products, and technologies.

Contingency theory states that an organization structures itself and behaves in a particular manner as an attempt to fit with its environment. Thus organizations are more or less complex as a reaction to environmental complexity. An organization's environment may be complex because it is turbulent, hostile, diverse, technologically complex, or restrictive. An organization may also be complex as a result of the complexity of its underlying technological core. For example, a nuclear power plant is likely to have a more complex organization than a standard power plant because the underlying technology is more difficult to understand and control.

There are numerous consequences of environmental and organizational complexity. Organizational members, faced with overwhelming and/or complex decisions, omit, tolerate errors, queue, filter, abstract, use multiple channels, escape, and chunk in order to deal effectively with the complexity. At an organizational level, an organizational will respond to complexity by building barriers around its technical core; by smoothing input and output transactions; by planning and predicting; by segmenting itself and/or becoming decentralized; and by adopting rules.

Complexity science offers a broader view of organizational complexity—it maintains that all organizations are relatively complex, and that such complexity arises that complex behavior is not necessarily the result of complex action on the behalf of a single individual's effort; rather, complex behavior of the whole can be the result of loosely coupled organizational members behaving in simple ways, acting on local information. Complexity science posits that most organizational behavior is the result of numerous events occurring over extended periods of time, rather than the result of some smaller number of critical incidents.

2. Organizational Complexity Defined

The concept of 'organizational complexity' is defined in a variety of different ways by different authors, and these different definitions lead to various operationalizations of the term. In discussing the general concept of complexity, Luhmann (1995) states "we will call an interconnected collection of elements complex when, because of imminent constraints in the elements' connective capacity, it is no longer possible at any moment to connect every element with every other element… Complexity in this sense means being forced to select; being forced to select means contingency; and contingency means risk" (p. 25).

The ability or inability for organizational entities to "connect" depends on the number of entities, and their diversity—it is easier to make connections between similar as opposed to dissimilar elements. The number of entities also in part drives the diversity of organizational entities; as size increases, then administrative functions must be added for the purpose of communication and coordination. Thus we can define organizational

complexity as *the amount of differentiation that exists within different elements constituting the organization*. In this manner, complexity is roughly equivalent to variety. Since organizations are about making sense and taking action, complexity impacts how easy it is for organizational members to make sense of their current perceptions, and the type of effort that is needed to determine and implement effective action.

Many studies operationalize organizational complexity in two ways: professional specialization and the associated level of required professional qualifications, typically measured by actual qualifications of the job holder, as opposed to the qualifications required by the job. For example, a restaurant would be considered to be rather low in complexity, since there are few job specialties (waiter/waitress, cook, dish cleaner, and perhaps matron), and each job requires minimal qualification, with perhaps the exception of the cook. A hospital would be considered to have quite great complexity, as there are numerous specialties (nurse, surgeon, family practitioner, radiologist, etc.), and many of those specialties require significant training and interned experience.

These two dimensions are not necessarily correlated. For example, a consulting firm may have workers representing few functional specialties (consultant, secretary, marketing), but the professional qualifications required for those specialties can be quite significant. The converse is not generally true however; organizations that have many functional specialties tend to have jobs that have distinct qualifications. Note also that organizations can, to some extent, choose where to distribute complexity. One firm may choose an organizational structure with high variety between groups and low variety

within groups; while another firm may choose an organizational design with loosely differentiated groups containing high diversity.

Professional specialization is not the only organizational characteristic that indicates organizational complexity, although it is one of the more indicative. Organizational complexity could also be defined as the amount of variety, or differentiation, in the organization's: core processes and technologies, customers and markets, products and product lines, distribution networks, suppliers, or geographical locations. For example, an organization such as a religious group may have little professional specialization and require little professional qualifications of its members, but could be considered complex because its membership stretches across geography and thus cultures and environment. Organizational complexity may also represent other types of variation in the workforce not necessarily associated with professional specialization. For example, gender difference is typically considered significant when examining the differences in beliefs and norms between doctors and nurses. Finally, diversity could exist in the causal processes underlying the work of the organization, leading to organizational complexity.

A simple way to quantitatively measure organizational complexity is to count the number of different categories that exist for the variable in question. In measuring the organizational complexity associated with job categories, one could refer to the formal organizational titles as embodied in job descriptions and records of the human resource department and count the number of job titles. This type of measure calls for clear articulation concerning the 'level of detail' that one associates with the job title; for example, should 'rank' be considered something that differentiates two otherwise

relatively similar positions? A raw count of the number of categories present does not take into account the fact that the distribution of these counts amongst the various categories may differ. For example, an organization with twenty accountants and one salesperson is probably not as complex as an organization with twenty accountants and twenty salespeople. Various entropy-based measures can take these distributional characteristics into account. The more uniformly spread the variation is amongst the different categories, the greater the measured complexity will be.

3. Antecedents of Organizational Complexity

At the simplest level, organizations are complex because the people constituting organizations are complex. This perspective leads us not to attempt to differentiate organizations as more or less complex than one another, but rather accept the fact that all organizations, regardless of their internal diversity, are complex. Schein (1980) points out that individuals vary tremendously in their age, gender, their histories and experiences, and their beliefs and desires. Even within a homogenous group of people who have the same professional qualifications and represent the same professional specialty, the diversity and thus complexity of the group must not be ignored. As Bateson said, there are many "differences that can make a difference", and job function is only one of them.

Besides the obvious interpersonal differences, Schein points out that people are capable of wearing many 'hats' within the organization, playing out various roles at different times. For example, an administrator may play the role of a bureaucrat, an accountant, a leader, a coach, a friend, and a team member, switching between these roles

with little apparent effort. People are often ‘matrixed’ into both a functional and project team category, and most are fully capable of enacting the beliefs and norms associated with the given role at an appropriate time, even though the roles may actually conflict with one another—most people are capable of dealing effectively with such role conflict, and for the most part, do not give it second thought.

Therefore, in attempting to develop programs aimed at, for example, employee motivation, we know that different people will be motivated by different things, and that a single individual is likely to be motivated by different things at different times. Thus, the complexity of human nature demands that managers be flexible, adaptive, experimenting, and learning.

More typically, organizational complexity is considered a response to complexity within the internal or external environment. The internal environment consists of the processes and technologies that constitute the core operations of the organization. The external environment includes customers, markets, suppliers, competitors, and institutions that shape what the organization must respond to. The complexity of the internal and external environment can be described along three dimensions: its differentiation or variety, its dynamic properties, and the complexity of its underlying causal mechanisms.

Consider the external environment first. Organizational scholars such as Thompson, March, Simon, Lawrence, and Lorsch have contributed theory and empirical evidence that states that organizations arrange themselves in such a way to react to environmental contingencies—thus a complex environment requires a complex organization. This follows the general principle within systems theory called ‘requisite

variety', which states that the complexity of a control system must be as least as great as the complexity of the system that is being controlled. In reality, of course, this can never be completely true—the organization's environment will always be more complex than the organizational itself. Nevertheless, an organization attempts to match its own complexity with that of the environment through differentiation: "differentiation into similar units (segmentation), the differentiation of center/periphery, the differentiation conforming/deviant (official/unofficial, formal/informal), hierarchical differentiation, and functional differentiation" (Luhmann, 1995, p. 190). Khandwalla (1977) reports some of the attributes that may lead to environmental complexity: turbulence, hostility, diversity, technical complexity, and restrictiveness.

A movie theatre is an example of an organization will low complexity, because its environment is characterized by low complexity. First, in terms of differentiation, the theatre's customers may be very diverse, but when it comes to sitting and watching a movie, all customers can essentially be treated the same. The only differentiation that exists is children versus adult, as enacted by the movie's rating. The theatre reduces any possible environmental variation in terms of the types of movies that people would like to see, or the type of food and beverages that they would like to purchase, by restricting variety in those components. Typically, only movies produced by one of the few major studios are ever even considered for showing.

The movie theatre is also low in complexity because elements of its environment are slow to change over time. The desires of people relative to movies have remained relatively unchanged for decades, and even the narrative structure of movies has changed little since the advent of talking films. What works today for a movie theatre will likely

work next year—in fact, innovations that theatres have taken on, such as a wider selection of food or video arcades, have not for the most part been successful. Finally, complexity in such an organization is low because the causal mechanisms that drive the organization's markets are simple—if people show up to the theatre, other people are likely to show up, and visa versa. Movie reviewers give theatre managers yet another way to estimate the potential market of the film.

An organization making computer peripherals is likely to be complex as a reaction to the complex environment it is a part of. First, the market needs are multiple and varied, and always dynamically changing. Second, the supply chain is also varied and dynamic; standards may not be adopted quickly enough to maintain pace with the markets and technologies, therefore compatibility is always an issue. Finally, causal mechanisms related to the external market are not simple, because adoption and diffusion processes are complex and unpredictable in the industry.

Organizations can also differ in complexity due to complexity in their internal environment—as Thompson (1967) refers to it, the organization's technologies. By technology, Thompson included the physical artifacts as well as the procedures, methods, and processes that constitute organizational action. As the organization's technologies become more complex, more specialists are required to understand the underlying causal mechanisms, and this subsequently requires greater effort at integration and coordination, again adding to the variety of tasks that the organization must do in order to function effectively. The movie theatre has relatively low complexity because the showing of the movie, including the technology that projects the film's images, is automated, and the business processes associated with selling tickets and food are straightforward. The

computer peripherals firm is likely to be significantly more complex, because the technology it is dealing with (micro-electronics) is often complex, especially when products are pushing the existing technological envelope.

Perrow (1984) differentiates the technologies within an organization as either being linear or complex. Linear systems are denoted by: spatial segregation, dedicated connections, segregated subsystems, easy substitutions, few feedback loops, single purpose controls, direct information, and extensive understanding. Examples would include dams, rail transport, assembly-line production, most manufacturing, and single-goal agencies (e.g. motor vehicles, post office). Complex systems are denoted by: proximity, common-mode connections, interconnected subsystems, limited substitutions, feedback loops, multiple and interacting controls, indirect information, and limited understanding. Examples would include nuclear plants, aircraft, chemical plants, space missions, military events, research and development, multi-goal agencies (e.g. welfare, department of energy), and universities. One would expect structural complexity and differentiation in such organizations with embedded technological complexity.

Finally, organizations may be complex as a response to their institutional environment—this is especially true for public segment organizations. Powell (1988) reports that public organizations "located in environments in which conflicting demands are made upon them will be especially likely to generate complex organizational structures with disproportionately large administrative components and boundary spanning units" (p. 126).

4. Consequences of Organizational Complexity

There are numerous consequences of environmental, and thus organizational complexity. For example, the amount of learning that goes on inside an organization is affected by environmental complexity. When environmental complexity is low, organizational members can succeed in their daily routines by maintaining status quo, and there is little incentive or need for learning. When environmental complexity is very high, organizational members are constantly barraged with demands for their attention, solving existing problems and scanning for new ones. This taxes the information processing capacity of the organization, and individuals tend to shut down, saving their energy for emergency needs that may arise. The opportunity for organizational learning is maximized when environmental complexity is moderate, pushing organizational members to learn new skills and solve problems, within the limitations of their ability to process information. For example, "learning" about new products and processes has been reported as low in the steel industry, where the environment is relatively simple, and in the Internet products industry, where the environment is very complex; conversely, learning is reported as significant in the automotive and semiconductor industries, two industries with middling levels of environmental complexity.

Environments can be complex simply because they are voluminous in their nature and demands, thus overwhelming organizational members with information. Organizational members respond in a variety of ways in order to reduce the stress of the information overload situation (Weick, 1995): individuals "begin with omission, and then

move to greater tolerance of error, queuing, filtering, abstracting, using multiple channels, escape, and end with chunking" (p. 87).

In addition to be voluminous and this overwhelming, the environment may also be complex because of its inherent nature. People deal with complex problems and decisions in several different ways (March, 1994). First, decisions can be broken down into their constituent parts and treated sequentially. Second, secondary and tertiary features of the decision may be ignored, allowing people to focus on only a few select issues. Third, people may draw from their experience, seeking solutions from previous problems, and minimizing their effort searching for entirely new solutions. Fourth, solutions can be chosen which satisfy, rather than optimize, the given situation, thus reducing the search effort. Fifth, people make assumptions about data that is not present, rather than going through the effort of questioning those assumptions, and/or seeking confirmation of their assumptions. Finally, people use stories and narrative procedures to convey information about complex situations that could not be readily assimilated via other modes of communication.

Thompson (1967) discusses theory concerning how an organization will respond to environmental complexity. First, following the norms of rationality, an organization is more likely to build barriers around its "technical core" if the environment is complex, surrounding it with input and output components. For example, engineers in a high technology firm rarely directly deal with customers, marketing or sales representatives do. Second, an organization will attempt to reduce the complexity of its environment by smoothing input and output transactions. For example, a school often requires its students (customers) to attend a fixed program of classes, rather than allowing them to

select from a broader array of offerings. Third, an organization will attempt to predict the amount of uncertainty and fluctuation in a complex environment. For example, hospital emergency rooms know there are peak times for medical emergencies and staff accordingly.

Fourth, an organization will segment itself in order to make its sub-environments relatively homogenous. For example, divisionalization along product lines enables the marketing function to focus on a reduced set of demographic groups. Fifth, organizations will adopt rules as a means to coordinate the less-complex aspects of its internal and external environments. For example, the military is a highly complex organization with many contingencies in its internal operations and external environment; however it operates with strict rules regarding (e.g.) communication protocol and behavior between members of different rank, in an attempt to minimize the uncertainty associated with at least part of its world.

Weick (1995) points out that as an organization operates under these "norms of rationality", it can lead to "a potentially incoherent assortment of issues to be managed by people at the top… This is precisely what we see in military command and control systems that are designed starting with the field and ending with people at headquarters. The issues left over for judgment, the portions most likely affected by deep decision premises of social class, ethnic origins, social networks, or national culture, and precisely those portions that defy order" (p. 116).

Mintzberg (1993) builds from Thompson's ideas and suggests that the more complex the environment, the more decentralized the organizational structure. He suggests that as the environment moves from simple to complex, and organization will

move from direct supervision to standardization of work processes, of outputs, of skills, and finally, mutual adjustment. Mintzberg separates the concept of complexity, having to do with comprehensibility, from that of stability or turbulence. His model states that in a complex but stable environment, the organization will choose standardization of its work processes and outputs. We can see this, for example, in the automotive industry, where interrelationships in the supply and distribution chain make operating very difficult to comprehend, but a stable environment allows for standardization, for example, of an organization's quality system according to ISO 9000 guidelines. Further still, an organization may simply standardize work skills; for example, the manner in which tenure is decided at major research universities represents such a decentralized bureaucracy. In a complex and turbulent environment, the organization will resort to mutual adjustment. For example, firms in the Internet industry mutually co-evolve standards (e.g. Java language) in order to maintain compatibility with one another. There are losers and winners in such mutual adjustments, but it is the only means by which to move forward at all.

5. Organizational Complexity and Complexity Science

Significant new scientific advancements in the area of complexity science (e.g. Anderson, 1999; McKelvey, 1997) highlight new ways in which we may think about and operationalize organizational complexity. Complexity science makes the assumption that all organizations are more or less "complex", and that complex behavior is not necessarily the result of complex action on the behalf of a single individual's effort; rather, complex behavior of the whole can be the result of loosely coupled organizational

members behaving in simple ways, acting on local information. Complexity science is a haven for positivists and constructivists, and has served as a common meeting place for the different research paradigms.

With roots in numerous disciplines, modern theories and models of complex systems, or more specifically, complex adaptive systems (CAS) focus on the interplay between a system and its environment and the co-evolution of both. CAS models extend traditional systems theory by explicitly representing the dimension of "time" and its related concepts. Internal to a CAS are agents. Depending on the scale of analysis, an agent may represent an individual, a project team, a division, or an entire organization. Agents have varying degrees of connectivity with other agents through which information and resources can flow. Agents possess schema that are both interpretive and behavioral. Schema may be shared amongst the collective (e.g. shared norms, values, beliefs, and assumptions) that make up an organization's culture, or may be highly individualistic. Agents behave so as to increase “fitness” of the system that they belong to either locally or globally. Fitness is typically a complex aggregate of both global and local states within the system.

Behavior in a CAS is induced not by a single entity but rather by the simultaneous and parallel actions of agents within the system itself. Thus, we refer to a system as self-organizing if it undergoes “a process . . . whereby new emergent structures, patterns, and properties arise without being externally imposed on the system. Not controlled by a central, hierarchical command-and-control center, self-organization is usually distributed throughout the system” (Goldstein in Zimmerman et al. 1998, p. 270). In other words, the behavior of a CAS is emergent. Emergence is “the arising of new, unexpected

structures, patterns, properties, or processes in a self-organizing system. These emergent phenomena can be understood as existing on a higher level than the lower level components from which [emergence took place]. Emergent phenomena seem to have a life of their own with their own rules, laws and possibilities unlike the lower level components." (Goldstein in Zimmerman et al. 1998, p. 265). Self-organization and emergence has been used to describe numerous social phenomena such as social movements, group dynamics, and open market economics.

What is intriguing is that such emergent behavior can be quite complex—highly varied and differentiated—having evolved from rules that are really quite simple. For example, the clustering behavior that one sees in spatial configurations of groups, whether it be birds in a flock or cars on a highway, is the result of a few simple rules (e.g. go the speed of your neighbor) acted upon locally. It is thus the nature of interaction between components of a systems, and the number of components, that determines whether the resulting behavior is complex or not, and if so, what type of complex pattern emerges.

Complexity theory highlights that most organizational behavior is the result of numerous events occurring over extended periods of time, rather than the result of some smaller number of "critical incidents". This represents a change in the manner in which organizations should be studied, because most existing methods emphasize (post-hoc) identification of key "turning points" in an organization's history in order to understand where it came from and what it's about. For example, the Minnesota Innovation Research Program (MIRP) studies (Van de Ven et al., 1999) found that innovations were not initiated on the spur of the moment, or by a single dramatic incident, or by a single

entrepreneur. An extended gestation period, often lasting several years, of seemingly random events occurred before concentrated efforts were launched to develop an innovation. Many of these divergent events were not intentionally directed toward starting an innovation. Some events triggered recognition of the need for change. Other events generated awareness of the technological feasibility of an innovation. Events such as these often "shocked" entrepreneurs into courses of action that, by chance, intersected with independent actions of others. These intersections provided occasions for people to recognize and access new opportunities and potential resources. Where these occasions were exploited, people modified and adapted their independent courses of action into convergent interdependent actions to mobilize efforts to initiate an innovation. Thus complex organizational behavior can be generated by the simultaneous and parallel actions of organizational members, sometimes resulting in a process that is relatively divergent process, and sometimes by processes that are similar to one another and convergent in nature.

Another useful complexity theory concept is that of Kauffman's rugged landscapes (1995). Complex adaptive systems evolve in such a manner so as to maximize some measure of "goodness" or fitness in a dynamic environment. The potential states that a system can attain can be represented by a "landscape", where the coordinates on the terrain represent the organizational configuration, and the height of the terrain represents fitness. The highest point in this landscape and its associated fitness value could be considered the optimal state for the system. When the organization's fitness landscape that is simple—e.g. single-peaked—it is relatively simple to optimize organizational performance. Managers must determine which factors are important, and

how those factors should be configured so that an overall organizational configuration best matches the contingencies of the environment.

If, however, the landscape is multi-peaked, with many local optima, then organizational optimization becomes difficult. Such complex, or “rugged landscapes” exist in problems where optimality of the organizational system is determined by tightly coupled components. When elements of the organization can be optimized individually without regard for one another, and this leads to global, systemic optimality, the landscape is simple (single-peaked). When individual components of the organization contribute to overall organizational fitness in different ways, depending on the value/state of other organizational components in a contingent manner, the optimal organizational configuration becomes difficult to find, as many configurations that “satisfice” exist. Thus, similar to Perrow’s formulation, an organization (or its environment) is considered complex to the extent that its constituent elements are interdependent upon one another. For example, successful production of engine turbines required deep knowledge of metal alloys, but also knowledge of how to interact successfully with suppliers. These two dimensions may well not be independent—an ability to leverage supplier knowledge may in fact counteract lack of local engineering expertise--so the two can be viewed as composing a complex landscape, where different configurations of "goodness" on the two dimensions correspond to different levels of "successful production".

6. Further Reading

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