COMPLEXITY THEORY

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The basic premise of complexity theory is that there is a hidden order to the behavior (and evolution) of complex systems, whether that system is a national economy, an ecosystem, an organization, or a production line. In business and finance, complexity theory places its focus on the ways a factory or company resemble an ecosystem or market, rather than a machine "whose parts and functions have been plucked out in advance," according to David Berreby. He maintains that the organization of systems is no accident, but "the results of laws of nature that we don't yet fully understand." Once understood, managers will learn that if left to function on their own, systems organize themselves, bringing about "order for free."

Proponents of complexity theory believe specific traits are shared by most complex systems. These systems are the combination of many independent actors behaving as a single unit. These actors respond to their environment, much as stock markets respond to news of changing economies, genes respond to natural selection, or the human brain responds to sensory input. All of these "networks" also act as a single system made of many interacting components. Complexity theory attempts to explain how even millions of independent actors can unintentionally demonstrate patterned behavior and properties that, while present in the overall system, are not present in any individual component of that system.

Complexity theory was founded on researchers's attempts to rationalize the behavior of large and complex systems, believing they cannot be explained by usual rules of nature. It attempts to discover how the many disparate elements of a system work with each other to shape the system and its outcomes, as well as how each component changes over time. It is also one way to express the perceived domination of systems over their myriad smaller influences.

While complexity theory is strikingly similar to chaos theory, complexity theorists maintain that chaos, by itself, does not account for the coherence of self-organizing, complex systems. Rather, complex systems reside at the edge of chaos—the actors or components of a system are never locked in to a particular position or role within the system, but they never fall completely out of control. As M. Mitchell Waldrop states in *Complexity,* "The edge of chaos is the constantly shifting battle zone between stagnation and anarchy, the one place where a complex system can be spontaneous, adaptive, and alive."

Sherry Turkle, author of *Life on the Screen* and professor of sociology of science at the Massachusetts Institute of Technology (MIT), feels that technology has helped bring the issues of complexity theory to life. She asserts that computers helped persuade us that knowing all the

parts of a system (or a computer) cannot give anyone the ability to foresee all the complexity that can arise as all of those parts interact.

ORIGINS OF COMPLEXITY THEORY

Much of the research on complexity theory originates from the Sante Fe Institute in New Mexico, a mecca for those studying complexity theory. George A. Cowan, head of research at the Los Alamos nuclear laboratory, founded the Santa Fe Institute in the mid-1980s. Scientists at the institute claim that through the study of complexity theory, one can see not only the laws of chaos, but also those of order—through which a powerful explanation for how any collection of components will organize itself can be generated.

One of complexity theory's leading proponents is Stuart Kauffman, author of *At Home in the Universe: The Search for the Laws of Self-Organization and Complexity.* Also a member of the Santa Fe Institute, Kauffman states, "Life exists at the edge of chaos I suspect that the fate of all complex adapting systems in the biosphere—from single cells to economies—is to evolve to a natural state between order and chaos, a grand compromise between structure and surprise." Kauffman's theories originated during his pre-medicine days, when his studies of genetics began to inspire questions about DNA and genetic structures. Kauffman felt that there had to be some kind of built-in order, that trial and error was too much of a long shot to be responsible for the perfect biomolecular structure of the human genome.

Other researchers with a stronger focus on the business side of complexity theory are Howard Sherman and Ron Schultz, authors of *Open Boundaries* and fellows at Santa Fe Center for Emergent Strategies in collaboration with the Santa Fe Institute. They believe business today is faster and nonlinear (effects are not proportional to their causes), and that "experts" cannot predict which products or companies will succeed. Sherman and Schultz assert that competitive advantage is fleeting, and that change can rapidly turn assets into dead weight.

Another major contributor to complexity theory is John Holland, a computer scientist and professor at the University of Michigan. Holland designed the genetic algorithm based on the idea that components of complex systems can be broken down into building blocks, whose characteristics can then be represented in code. In simulations, units of code recombine to make "offspring"; the best of these offspring are allowed to reproduce, while the worst are discarded. As the algorithm works, better code evolves, and the results can be translated into real-world applications.

DETAILS OF COMPLEXITY THEORY

A complex system is defined as one in which many independent agents interact with each other in multiple (sometimes infinite) ways. This variety of actors also allows for the "spontaneous self-organization" that sometimes takes place in a system. This self-organization occurs without anyone being in charge or planning the organization. Rather, it is more a result of organisms/agents constantly adapting to each other. The complex systems are also adaptive (i.e.,

they always adapt in a way that benefits them). As an analogy, Waldrop suggests analogy to the way the human brain adapts to learn from experience.

Another important concept in complexity theory is that there is no master controller of any system. Rather, coherent system behavior is generated by the competition and cooperation between actors that is always present. And the components of a system do have different levels of organization—like an organization made up of divisions, which contain different departments, which are in comprised of different workers. But the important differentiation from this "organization," made by John Holland in *Complexity,* is that "complex adaptive systems are constantly revising and rearranging their building blocks as they gain experience. A firm will promote individuals who do well and (more rarely) will reshuffle its organizational chart for greater efficiency. Countries will make new trading agreements or realign themselves into whole new alliances."

Another important part of complexity theory is its assumption that there are principles underlying all "emergent properties," or traits that emerge from the interactions of many different actors. David Berreby uses the analogy of an ant colony that switches to a better food source. No individual ant made the decision; it was a result of their interactions.

One of the defining characteristics of complex systems is the inability to predict the outcome of any given change to the system. Because a system depends on so many intricate interactions, the number of possible reactions to any given change is infinite. Minor events can have enormous consequences because of the chain of reactions they might incite. Conversely, major changes may have an almost insignificant effect on the system as a whole. Because of this, strong control of any complex system may be impossible. While it may have order, no one absolutely governs a complex system.

Scientists create computer simulations that enable them to better identify emerging patterns in a system. They also write modification programs allowing system components to adapt to changes in the environment without the absolute necessity of radical changes to the overall structure. Computers can use these simulations to design production schedules and optimize assembly line performance.

COMPLEXITY THEORY IN BUSINESS

Complexity theory is used in business as a way to encourage innovative thinking and real-time responses to change by allowing business units to self-organize. Sherman and Schultz (as related by Hout) argue that modern business moves in a nonlinear fashion, with no continuity in the flow of competitive events, except when observed from hindsight. In order to effectively put complexity theory to work, however, organization leaders need to give up rigid control of these systems from above. Far more can be learned by stepping back from the day-to-day running of the organization and watching for emergent properties and organizational patterns. Those conditions or patterns that bring about the best solutions should be preserved whenever possible. Managers also need to allow organizations to evolve in response to ongoing messages from customers. As Hout states:

No intelligence from on high can match the quality of solutions to market problems that arise from players who are constantly communicating with one another on the ground level. The invisible hand of the marketplace should displace the visible hand of the manager. The markets can determine where one team or initiative or company ends and another begins. Managers interfere at their peril.

Efforts to downplay management, as related by Hout, claim that "management as we have known it is too cumbersome for today's fast, unpredictable pace. A new kind of company wins now. The best management models don't adapt to the new economy; they emerge from it. It's no longer the survival of the fittest; it's the arrival of the fittest." Even so, putting the ideas of complexity theory to work does not mean management need rest on its laurels. Hout asserts that organizations's leaders retain an obligation to formulate a guiding vision for the company, provide effective leadership, express and encourage strong values and organizational beliefs, and provide avenues for open communication. Managers need to manage the way that accident and law interact, knowing how and where to push to keep the system from neither descending into chaos nor becoming rigidly ordered.

Letting an organization self-organize does not negate the need for strategy. Rather, it means that organizational strategy should evolve based on feedback and change as it occurs. By establishing a corporate strategy first, an organization defines itself through conditions that were previously in place, and becomes non-adaptive to continuously-evolving market conditions. Sherman and Schultz recommend the "try something and see what happens" mentality.

CONTRARY BELIEFS

The idea that allowing complex systems to self-organize will yield the best solutions has validity, but complexity theory is not a panacea for all organizations. The notions of complexity theory assume that people in these companies are enthusiastic, intelligent, and can effectively work in teams—requiring less management than workers in more traditional, hierarchical, rigidly-controlled environments. Unfortunately, however, these fast-growing, evolutionary companies with bright, ambitious workers may need more management rather than less. Companies that are shaped and reshaped on such a frequent basis—constantly adapting to a changing business environment—lose some of the stability found at traditional corporate giants such as the industrial and automotive behemoths.

The modern corporation has a lot at stake. There are difficulties in teamwork and collaboration, with potential issues such as nonperforming team members, personality conflicts, opposing business styles, and the effects of stress on job performance. Organizational leaders need to effectively manage personnel and job performance, reward and groom talented performers, develop business relationships and networks, resolve conflict, and divest the company of nonperformers who may be holding the company back from adapting well to emerging trends and technologies. Other business leaders see emergent strategy as a problem, rather than a cure. According to Alan Kay, head of research and development at Disney Imagineering, "Most businesses do not move so fast that foresight, commitment, preemption, deterrence, and other traditional elements of strategy have lost their ability to build value. The best way to predict the future is to invent it."

Complexity theory and the Santa Fe Institute represent common ground where scientists and theorists from disciplines such as economics, physics, business management, and computer science can research behavior of complex systems and their various components. The complexity paradigm also offers a means of applying modern theories that an organization is more like a living organism than a machine. Organizations are conceptualized as evolving in response to complex interactions within and without the system.

Ron Schultz, co-author of *Open Boundaries,* explains that complexity theory "is about how our ideas shape our behaviors. If our ideas about the world in which we operate are machine-like and mechanical, our behaviors will be very different than if our ideas are based on that of complex adaptive systems, which are more evolutionary and organic." Rather than following more linear approaches to corporate decision making, complexity theory offers organizations a way to thrive on the ambiguity and unpredictability that characterize modern business.

Some of complexity theory's leading experts, such as J. Doyne Farmer and Norman Packard, make a living advising companies and practically applying the ideas behind complexity theory to business areas such as corporate investment. Organizations putting the theory into practice include Xerox's Palo Alto Research Center (PARC), Applied Biosystems, and the United States Marine Corps. Complexity theory offers companies the opportunity to create new markets and establish new ways to spread emerging knowledge throughout the company—enabling the organization, as a whole, to respond faster and better to ongoing change.
http://www.referenceforbusiness.com/management/Bun-Comp/Complexity-Theory.html

SEE ALSO: Chaos Theory ; Managing Change ; Organizational Behavior ; Trends in Organizational Change

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