complexity theory

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Complexity theory provides an understanding of how systems (such as the telecommunications industry, stock markets, the internet, the economy, and global corporations) grow, adapt, and evolve. It explains how the relationships between members of these systems give rise to collective behavior. For example, it describes how the interactions between competing telecommunications firms gave rise to the industry-wide GSM standard. Complexity also sheds light on how a system interacts with its environment, as in the case of the interactions among business units within a global company, or the rounds of negotiation and adaptation between corporations and regulators.

Complexity theory does not need to have a complex explanation. The principle of Occam's razor encourages us to simplify complexity, where possible, for the study of organizational change. The discussion can be simplified by delineating the difference between *complicated* and *complex* systems. Complicated requires attention to detail whereas complexity calls for attention to the behavior of the whole system.

A complicated system, such as a thesaurus, is rich in detail. A complex system, such as a multinational organization, is rich in structure. Managers are used to dealing with problems that are complicated and that requires attention to detail. Getting the task done is the primary objective, whether they are running a department, an IT system or a multinational company. Problems are broken down into constituent parts. Experts are engaged to solve each part within a management hierarchy. This approach is challenged when applied to problems that are complex, such as managing the growth of a fast-moving technology company. The rules keep shifting with changes in corporate and economic environments, and the organization keeps reorganizing itself to handle such shifts. An action on one part of the problem affects the behavior of another part and the company evolves into a complex web of interactions and activities that shift and adapt according to the situation at hand. At this point, the organization moves from a complicated mode of handling day-to-day matters to a more complex mode of operation. It evolves and adapts with its internal systems (such as different divisions) and its external environments (such as economic, technological, and market environments).

Complexity theory partly explains how organized systems emerge out of chaotic situations. Corporations are not viewed merely as complicated, static organizations, but as a complex set of self-organizing components made up of employees, business units, resources, and stakeholders. The value of complexity theory to organizational research is its ability to account for the development of new structures within an organization (such as the consumer-to-consumer market on eBay) and the development of new business models (such as the "free content" model of Google).

Complexity theory recognizes that economic and organizational phenomena are similar to those observed in science and in nature. The best way to understand the similarity is to look at the key components of complex systems:

Increasing returns. The concept of "increasing returns" has its roots in economic theory, evolutionary theory, and in recent studies on complexity dynamics. With the arrival of network technologies, attention has focused on mechanisms of increasing returns in both the demand and the supply side of the economy. In evolution, selection theory reflects increasing returns whereby stronger species grow stronger because of their ability to claim resources and to reproduce. In complexity theory, increasing returns are a form of positive feedback, reflected in our linguistic expressions. Statements such as "the rich grow richer" and "success breeds success" demonstrate our intuitive understanding of positive spirals of behavior and performance.

Self-organizing systems. An example of a self-organizing system is a flock of birds. The formation is formed by the subconscious rules followed by each bird such as maintaining a fixed distance from its neighbor. The result is a configuration that seems to have its own life, which is capable of moving in harmony without a leader or external control. The process is bottom-up starting with a few simple rules for individuals, which create a flowing complex system.

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The dynamics of supply and demand in an economy operate in the same way. Pricing strategy and purchasing decisions are adjusted in a self-organizing manner. The effect is termed "emergent" self-organization. It explains the behavior of traders in the stock market who decide the value of a flotation and determine future share value. The emergent behavior is visible in thousands of transactions on the market place.

Continuous adaptation can be seen in the stock market where investors collect and analyze information and react to it. This is a spiraling feedback loop of modifying behavior to the situation of other components in the environment. The resultant behavior will modify the environment and vice versa. Complex adaptive behavior is evident in the following examples: the global economy, emerging cities, online social networks, and the internet as a constantly evolving network of information and services. In ecology, examples of complex adaptive behavior are observed in the immune system, neural network, swarms, and rainforests. When environments are competitive and aggressive from the start-up phase, cooperation emerges between the parties for the benefit of all. This type of evolving cooperation is seen in the mobile telecommunications industry. Companies form alliances to set new technology standards and increase the compatibility of their networks (*see* COMPLEX ADAPTIVE SYSTEMS).

Sensitivity to initial conditions is seen in chaotic systems such as the weather. The "butterfly effect" symbolizes this process. The theory of complexity shows how two systems starting out in similar, but not necessarily identical environments, will develop entirely different scenarios. This happens because of the adaptation effects within the system and nonlinear dynamics. The units within the system cooperate and adapt to each other creating different organized scenarios. Long-term predictions are thus impossible.

The reaction of investors to critical events such as war has explosive effects on share prices. This implies hyper-movements at certain critical points. Technical analysts call the threshold points "supports" and "resistances." The terms refer to the concept that decision making on buying and selling are partly due, on both the personal and market levels, to psychological reasons.

Nonlinearity occurs when the total effect of interacting agents is greater than the sum of the parts. The whole has features and characteristics that are beyond the capacity of its respective component parts. The behavior is nonlinear in nature as certain inputs will have a disproportionately strong effect on others. Stock markets exhibit a similar form of nonlinearity as the combined actions of investors, feedback on themselves, and create bull and bear markets.

See also *complex adaptive systems*; *critical mass*; *first mover advantage*; *network externalities*; *strategic networks*; *technology and standards in network industries*

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