Complex Adaptive Systems

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complex adaptive systems

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Definition

Complex adaptive systems (CAS) consist of diverse components (called agents) that are interdependent, act as a unified whole, and have the ability to learn from experience and to adapt to change in the environment.

Examples of CAS are the global economy, stock markets, emerging cities, online social networks, and the internet. In ecology, examples of CAS would be neural networks, swarms, and rainforests.

Relevance to Strategic Management

The insights from CAS that are significant to strategic management are the high degree of adaptive capacity and the resilience in the face of disruptive change. Strategists would benefit from an understanding of how to create businesses that react and adjust rapidly to changing market conditions, and that are able to innovate and evolve in difficult economic environments.

Complexity theory provides an alternative lens to economic theory when observing organizations, industries, and economies. The point of departure of the complexity perspective draws from behaviors observed in physics and biological systems. Complexity theory brings in an evolutionary perspective to explain how markets work and what organizations and industries do to survive and evolve.

What complexity brings into the equation is a set of insights on how to encourage market processes by adopting the features of CAS (adaptation, emergence, self-organization, and cooperation described later) to create more responsive and agile organizations. For a more detailed discussion of complexity dynamics, *see* COMPLEXITY THEORY.

Adaptive Behavior

Adaptive behavior is the common ground between the traditional perspective of market processes and CAS. Economics and complexity provide a similar view of the outcomes of the interactions of supply, demand, and other self-correcting mechanisms. The difference lies in the assessments employed to describe the same phenomenon.

Adaptive behavior can be seen in the stock market where investors collect and analyze information and react to it. This is a feedback loop of modifying behavior that changes the parameters of other components in the environment. An increase in the demand for shares would in turn increase their price. A decrease in demand, as a reaction to economic conditions, decreases the share price. The actions and reaction modify the stock market prices and vice versa. The analogy in ecosystems is that fast lions lead to faster gazelles, which would lead to even faster lions. The faster gazelles will survive to pass on their genes, and only faster lions would be able to prey on them and survive.

The international telecommunications industry is another example of complex adaptive behavior. It consists of several "interacting agents" at the organizational level in the form of regulators, network infrastructure providers, technology suppliers, and consumer markets, which interact and adapt to each other. Regulators respond to market forces with new legislation. Network providers in turn react to the regulators' requirements. Technology suppliers drive the development of the industry and adjust to the needs of the end consumers and network providers. The cycle of adaptation creates innovation and continuous change in the industry. The speed at which these natural processes work require a new and different kind of competence that can handle the complexity of fast moving markets, technologies, and industries.

Emergent Behavior

In a typical CAS, the "interacting agents" exhibit the traits of emergent behavior where there is *no visible leader* and the whole system is driven by a collective force. The telecommunications industry is driven by all four interacting agent groups (regulators, network providers, technology suppliers, and consumers) as they act, react, and evolve as a whole unit. The evolution of the industry is determined by the collective interactions and adaptations of all the

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four agent groups. The way the telecommunications industry works shows signs of collective intelligence through the way its component groups learn, react, and evolve around each other.

Emergent behavior is also observed in thousands of transaction in consumer markets. The dynamics of supply and demand in an economy operate without a single leader and are driven by a collective form of leadership in a "self-organizing" manner. Self-organizing behavior in the market place is reminiscent of Adam Smith's metaphor of the "invisible hand" used to describe the self-regulating behavior of the marketplace. Kauffman (1993) captures the essence of self-organization in his statement that, contrary to our intuitive thinking, chaotic and disordered systems can spontaneously "crystallize" toward a very high degree of order. The development of Wikipedia is a good example of how widely dispersed information across several disciplines has been shared, updated, and disseminated in a self-organizing manner.

A CAS starts to self-organize with *simple rules and goals* (such as the paradigm of free distribution of internet content) which in the long run gave rise to an organized complex formation (such as the ever evolving volume of internet content). The end result is a configuration that seems to have its own life, which is capable of moving in harmony without external control. The rules are not strict and are better described as tendencies.

Emergent behavior is visible in markets that evolve rapidly, have no visible leader, are driven by a set of simple rules, and have a tendency to "self-organize" without a central controlling force. The internet is a case in point. It did not have a single driving force – in fact, it seemed to have several driving forces moving it forward, namely the technologies of internet browsers and search engines. The initial drive came from technology rather than profit, which is the main mechanism of the market processes described in economics. The internet ran on the simple rules of free content and free information. It rapidly self-organized into a complex industry of content providers, content consumers, search engines, internet browsers, and online enterprises.

Cooperative Behavior

Cooperative behavior in a complex adaptive system enables organizations in an industry to change, evolve, and grow rapidly. The internet required the wide spread cooperation of technology firms to develop compatible network platforms and common industry standards. A CAS covers more parameters than just price and quantity in a world where innovation, product specifications, and quality are all changing subtly but rapidly. Competition and collaboration arise between agents in a CAS, driven by the mutual benefits of collaboration. Alliances emerge at every level and in every kind of CAS, from ecology to economics to politics. Competition can sometimes become the driving force behind cooperation. For example, competing firms in the telecommunications industry are observed to spontaneously forge alliances and symbiotic relationships in order to grow the industry. When firms cooperate, they can develop compatible networks and they can grow the extent of their network infrastructure. The larger the infrastructure is, the more the consumers can be reached over the network and the higher the revenues will be for the respective firms. In larger industries there are more players and therefore a higher probability that a larger number of companies will survive and flourish.

Business Models and CAS

It would be a high-risk strategy to intentionally transform existing business models and organizational structures into completely self-organizing ones. However, the potential of CAS and the positive impact on revenues and profits are becoming more evident to managers of traditional businesses.

eBay, Amazon, and Kindle Direct Publishing appear to be a form of CAS with self-organizing exchanges. They have created an evolving network of individual suppliers, which require little control or guidance, and which simultaneously act as customers. The organizations have intelligently developed new ways of creating business and have generated more revenues than typical hierarchical retail stores and publishing houses. eBay and Amazon started out as hierarchical businesses that cleverly created the right environment for self-organizing systems

to flourish within is supplier base (businesses and consumers placing items for sale) and its consumer base.

Strategic thinkers at internet-based companies such as Twitter, Facebook, LinkedIn, and Amazon have an intuitive understanding of CAS, which enables them to exploit the power of crowdsourcing – the wide spread gathering of free internet content and information from a global network of sellers and buyers. Riding the wave of how millions of consumers simultaneously contribute and use these networks, these companies have created new and highly profitable business models.

Hybrid business models are seen in both internet businesses and the more traditional companies. Companies have encouraged hierarchical structures and CAS to exist side by side. Vodafone and Comcast, for example, give frontline employees increasing discretionary powers – allowing executives in the field to take decisions on site, rather than having to wait for decisions from headquarters. In the digital age, the ability to share complex data between head office and customer-facing units gives hierarchical companies the ability to encourage self-organization.

Building CAS into a business strategy may be risky because these systems cannot be directed to take a predetermined course, and the end result is unpredictable. On the other hand, the experience of highly profitable companies such as Google, eBay, Amazon, and Facebook provide business insights on how fostering CAS, within an organization and its markets, can be a viable competitive strategy.

See also *complexity theory*; *coopetition*; *networks*; *network externalities*

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