

Strategy and Complex Systems
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[updated: Saturday, July 5, 2025]

“Today the network of relationships linking the human race to itself and to the rest of the biosphere is so complex that all aspects affect all others to an extraordinary degree. Someone should be studying the whole system, however crudely that has to be done, because no gluing together of partial studies of a complex nonlinear system can give a good idea of the behavior of the whole.”

---Murray Gell-Mann (1929–2019)

“Don’t bring a knife to a gunfight.”

---“The Untouchables” (movie, 1987)

Purpose:

The primary purpose of this document is to explore the details of complexity in general, and complex systems, specifically, in the context of business strategy.

Some organizational ideas and pedagogical structure came from the following book:

Mitchell, M. (2011), *Complexity Science: A Guided Tour*, Oxford University Press.

To assist in further study, the definitions in this document regarding complex systems were excerpted and adapted from the Wikipedia page:

https://en.wikipedia.org/wiki/Complex_system

A gentle introduction for business students to some aspects of Complexity can be found in the following book:

Jolly, R. (2015), *Systems Thinking for Business: Capitalize Structures in Plain Sight*, Systems Solutions Press.

An in-depth examination of the role of systems thinking in the modern economy is:

Beinhocker, E. (2007), *The Origin of Wealth: The Radical Remaking of Economics and What it Means for Business and Society*, Harvard Business Review Press.

The specific goal of this document is to help student-professionals incorporate various aspects of complex systems into the formal and informal processes

associated with strategic visioning and strategic execution, including all of the technical, detailed analyses that accompany both of those two strategy components.

Rigorous and relevant application of complex systems should help improve our modeling and judgment, both in a quantitative (numbers) sense and in a qualitative (words) sense. At worst, a working knowledge of complex systems helps us understand the limitations of our strategic modeling. At best, complex systems holds the potential to improve successes and mitigate against failures in a variety of organizational purposes and contexts.

Each of the ideas below are in four general parts: 1), the name of concept, 2), a pithy quote (mnemonic) to help remember the concept, 3), a brief definition or outline of the concept, 4), an idea from one or more articles, situations, or incidents as an example(s) of the concept, and 5), a brief analysis of the issue or a link to other parts of this course or a business student's curriculum.

Key Concepts of Complex Systems:

A complex system must exhibit at least one of the following key concepts.

Complexity:

"Everything should be made as simple as possible but no simpler."

"Systems exhibit complexity" means that their behaviors cannot be easily inferred from their properties. Any modeling approach that ignores such difficulties or characterizes them as noise, then, will necessarily produce models that are neither accurate nor useful.

(Challenge)

We can train a minimize wage worker to make a shoe but we can't develop a robot to make a shoe?

Emont, J. (April 22, 2025), "Nike Finds Robots Struggle to Make Shoes", *Wall Street Journal*.

Emergence (over scale):

"Often, you can't see the forest for the trees."

Another common feature of complex systems is the presence of emergent behaviors and properties: these are traits of a system that are not apparent from its components in isolation but which result from the interactions, dependencies, or relationships they form when placed together in a system.

(Challenge)

Are there some issues that are so complex that even well-funded, smart companies can't figure them out? Also, how can a partnership of Amazon, Berkshire-Hathaway, and J.P. Morgan know, *in advance of trying*, that an initiative might not work? How come some issues only arise at certain scales?

Grant, C. (May 29, 2021), "EXCHANGE --- Heard on the Street: A \$4 Trillion Medical Mystery --- Tech and retail giants face numerous obstacles in their efforts to solve the healthcare puzzle", *Wall Street Journal*.

Self-Organization (over time):

"Birds of a feather flock together."

Self-organization, also called spontaneous order, is a process where some form of overall order arises from local interactions between parts of an initially disordered system. The process can be spontaneous when sufficient energy is available, not needing control by any external agent. It is often triggered by seemingly random fluctuations, amplified by positive feedback. The resulting organization is wholly decentralized, distributed over all the components of the system.

Even with the best strategy and solid fundamentals of Finance, Marketing, and Operations (opportunity), just the ego and culture of one individual or one firm could sink an idea (challenge). Also, how do we, at the end of the day, evaluate the tradeoffs between what's best for the customers and what's best for the investors? Passy, J. (June 18, 2025), "The Future of Everything: The Travel Issue --- One Rewards Plan for All Your Travel? Loyalty programs evolve as airlines and hotels explore one-point-fits-all systems.", *Wall Street Journal*.

Key Dimensions of Complex Systems:

Broadly, a complex system can be classified into one of the following seven (7) dimensions. These classifications are not necessarily mutually exclusive.

Collective Behavior:

"Really, the only thing that makes sense is to strive for greater collective enlightenment."

The study of complex systems is an approach to science that investigates how relationships between a system's parts give rise to its collective behaviors and how the system interacts and forms relationships with its environment. The study of complex systems regards collective, or system-wide, behaviors as the fundamental object of study; for this reason, complex systems can be understood as an

alternative paradigm to reductionism, which attempts to explain systems in terms of their constituent parts and the individual interactions between them.

Networks:

“The world is made up of things that you can but is held together by things you can’t see.”

The interacting components of a complex system form a network, which is a collection of discrete objects and relationships between them, usually depicted as a graph of vertices (objects) connected by edges (relationships). Networks often describe the sources of complexity in complex systems.

How do we incorporate slow, incremental—almost invisible—data into the conceptual model and analytical model of the value proposition of an asset? Is it really possible that the maintenance of an asset can significantly alter our perception and use of an asset? How come improvements in technology don’t necessary come with improvements in maintenance of the same technology? Neil, D. (June 21 - 22, 2025), “OFF DUTY --- Gear & Gadgets: Driven to Despair --- Our love affair with automobiles is draining our wallets, with new vehicles increasingly out of reach and repair costs sending cars to the scrapper before their time. Can the relationship be saved?”, *Wall Street Journal*.

Evolution and Adaptation:

“Being different will always threaten the institution of understanding of a closed mind. However, evolution is built on difference, changing and the concept of thinking outside the box. Live to be your own unique brand, without apology.”

Complex adaptive systems are special cases of complex systems that are adaptive in that they have the capacity to change and learn from experience. It is an ensemble composed of dynamic network interactions, but the behavior of the ensemble may not be predictable according to the behavior of the components. It is adaptive in that the individual and collective behavior mutate and self-organize corresponding to the change-initiating micro-event or collection of events. In the social sciences, learning from and integrating with its environment is also part of evolution and adaptation.

(Opportunity and Challenge...it’s both, simultaneously)

It’s not just individuals and organizations that change; societies and institutions do too.

Terlep, S. (June 18, 2025), “The Future of Everything: The Travel Issue --- Hybrid-Electric Comes to Planes: Marc Allen, CEO of aerospace startup Electra, on why he

thinks a quiet plane that can take off from a surface no bigger than a soccer field will change the way we fly.”, *Wall Street Journal*.

Pattern Formation:

“Pay attention to the intricate patterns of your existence that you take for granted.”

The science of pattern formation deals with the visible, statistically orderly outcomes of self-organization and the common principles behind similar patterns in nature. Some patterns exhibit symmetry. Chaos theory ranks as an essentially universal influence on patterns.

Systems Theory:

“Systems Thinking is the discipline for discerning relationships and context that are not obvious.”

Complex systems are chiefly concerned with the behaviors and properties of systems. A system, broadly defined, is a set of entities that, through their interactions, relationships, or dependencies, form a unified whole.

(Opportunity)

In addition to selling products (i.e., Amazon), also sell to others the technology infrastructure (cloud computing) than Amazon runs on (i.e., Amazon Web Services). Greene, J., and L. Stevens (June 2, 2018), “EXCHANGE --- How Amazon Wins --- As the company relentlessly gobbles up markets in the lucrative cloud business, some partners thrive while others fear a giant competitor”, *Wall Street Journal*.

Nonlinear Dynamics:

“People take the longest possible paths, digress to numerous dead ends, and make all kinds of mistakes. Then historians come along and write summaries of this messy, nonlinear process and make it appear like a simple, straight line.”

In linear systems, the effect is *always* directly proportional to cause. Complex systems often have nonlinear behavior, meaning they may respond in different ways to the same input depending on their state or context. In nonlinear systems, a small perturbation may cause a large effect, a proportional effect, or even no effect at all.

Jakob, S. (December 2, 2023), “EXCHANGE --- Heard on the Street: The Math Behind The Megaships --- The cruise industry is bringing a whole new meaning to the phrase 'economies of scale'.”, *Wall Street Journal*.

Levinson, M. (October 24, 2020), "REVIEW --- The Megaships That Broke Global Trade --- With a new generation of giant container ships, firms and governments made a big bet on the future of globalization -- and lost.", *Wall Street Journal*.

Campo-Flores, A. (April 30, 2015), "Bigger Ships Snarl U.S. Ports --- Logistical challenges, delays prove costly to retailers as cargo volumes grow", *Wall Street Journal*.

Faucon, B., Paris, C., and J. Smith (March 29, 2021), "World News: Shippers Reroute, See Delays, Losses Ahead --- Billions of dollars in global trade are held up because of vessel that blocked Suez Canal", *Wall Street Journal*.

Game Theory:

"When you strip away the genre differences and the technological complexities, all games share four defining traits: a goal, rules, a feedback system, and voluntary participation."

Game theory is the study of mathematical models of strategic interaction among rational decision-makers. For example, sensible decision-making is critical for the success of strategy. In strategic management, game theory is used to model the decision-making process of players, such as investors, project managers, contractors, sub-contractors, governments and customers. Quite often, these players have competing interests, and sometimes their interests are directly detrimental to other players, making strategic management scenarios well-suited to be modeled by game theory.

(Challenge)

A partnership is needed to start and build a fledgling firm. However, how can a partnership know, preferably *in advance*, that the interests of both parties might diverge (rather than converge)? Finally, how do know whether a previously a key cooperator might become a chief competitor?

Berber, J. (June 17, 2025), "OpenAI, Microsoft Tensions Are Reaching a Boiling Point --- Startup, frustrated with its partner, has discussed making antitrust complaints", *Wall Street Journal*.

Key Features of Complex Systems:

A complex system may have one or more, often many, of the following features. These features are not necessarily collectively exhaustive.

Cascading Results:

“The chain is only as strong as its weakest link, for if that fails the chain fails and the object that it has been holding up falls to the ground.”

Due to the strong coupling between components in complex systems, a failure (or success) in one or more components can lead to cascading failures (or successes) which may have catastrophic (or beneficial) consequences on the functioning of the system. Localized attack (or net gain) may lead to cascading failures (or increasing returns) and abrupt collapse (or growth) in spatial networks.

(Challenge)

Do you know all of the touchpoints in the infrastructure that enables your modern life?

In the 2025 Spring semester at CSU Northridge, one of two cars involved in a traffic accident off-campus hit a power pole. There were no injuries at the scene.

However, the affected power pole ripped the power line, and the power was cut.

The power to the entire CSUN campus was affected. The accident occurred just after 5:00pm and no timeline for restoration was known by the campus administrators.

Subsequently, all the evening's 6:00pm and 7:00pm classes that evening were cancelled. Power was restored sometime later and classes resumed the following morning.

Complex Systems May Be Open:

“Note that there is not a focus on eliminating failures. Systems without failures, although robust, become brittle and fragile. When failures occur, it is more likely that the teams responding will be unprepared, and this could dramatically increase the impact of the incident.”

Complex systems are usually open systems — that is, they exist in an environment from which they can both consume and dissipate energy. In other words, complex systems are frequently far from equilibrium.

This new, small truck from an American firm and made in America is estimated to be available in late 2026 at a price of about \$30,000. What's interesting, also, is that nearly all of the Computer Aided Design (CAD) models and software used to manufacture the light truck will be open source, therefore enabling owners to nearly completely (within safety requirements, of course) change and improve the vehicle over time. How does a firm know what its true relationship is with the dynamic environment? How does a firm know what a customer is going to do with a product over time? Should a firm admit that it can't hire all the smart people in the world? Neil, D. (May 3, 2025), “OFF DUTY --- The Money Issue: Gear & Gadgets -- Rumble Seat: A Small, Affordable Pickup? Hell Yeah.”, *Wall Street Journal*.

Complex Systems May Exhibit Strong Transitions:

“Look on every exit as being an entrance somewhere else.”

Critical transitions are abrupt shifts in the state of ecosystems that may occur when changing conditions pass a critical point, often called a bifurcation or “tipping” point.

(Opportunity)

How do incorporate qualitative (words) data into our quantitative (numbers) models?

Ramkumar, A. (June 18, 2025), “Senate Passes Bill Regulating Stablecoin”, *Wall Street Journal*.

Complex Systems May Have a Memory:

“Your memory is a monster; you forget—it doesn't. It simply files things away. It keeps things for you, or hides things from you—and summons them to your recall with will of its own. You think you have a memory; but it has you!”

Recovery from a critical transition may require more than a simple return to the conditions at which a transition occurred. The history of a complex system may thus be important. Because complex systems are dynamical systems, they change over time, and prior states may have an influence on present states.

Complex Systems May Be Nested:

“Throughout the living world, we find living systems nesting within other living systems.”

The components of a complex system may themselves be complex systems. For example, an economy is made up of organizations, which are made up of people, which are made up of cells - all of which are complex systems. This structure promotes a system's capacity to persist under increasingly harsh circumstances as well as the potential for large-scale systemic regime shifts.

Dynamic Network of Multiplicity:

“It's the people we hardly know, and not our closest friends, who will improve our lives most dramatically.”

As well as coupling rules, the dynamic network of a complex system is important. Small-world or scale-free networks which have many local interactions and a smaller number of inter-area connections are often employed. Natural complex systems often exhibit such topologies. In the human cortex for example, we see

dense local connectivity and a few very long axon projections between regions inside the cortex and to other brain regions. Of course, the reverse could also be true in other sociological rather than biological examples.

Relationships Contain Feedback Loops:

“Feedback is the bridge to effectively connect lessons-learned from the past to the future performance and potential.”

Both negative (damping) and positive (amplifying) feedback are always found in complex systems. The effects of an element's behavior are fed back in such a way that the element itself is altered.