COMPLEXITY THEORY, SENTIMENT AND SUPPLY CHAIN ORGANIZATIONAL BEHAVIOR
ABOUT THIS REPORT

Applying high-level complexity theory to supply chain management practice is a relatively new area of study. Today’s supply chains are both complex and complicated. This report highlights the difference between complexity and complication in ways that add greater understanding to supply chain partner relationships. Traditionally we see supply chains in terms of complicated but predictable flows of products, information and finance. Rarely do we see the complex flow of changing supply chain partner relationships, meaning the flow of changing trust, sentiment and goodwill across supply chain partnerships. These changing social relationships bring about unexpected good and bad results across the supply chain. This report provides a look at supply chain complexity and actionable steps to prevent complexities from leading to poor outcomes.

APICS Supply Chain Council is pleased to bring you thought-provoking analysis of this topic. This report was developed by APICS SCC, a nonprofit organization that advances supply chains through unbiased research, benchmarking and publications. APICS SCC maintains the Supply Chain Operations Reference (SCOR) model, the supply chain management community’s most widely accepted framework for evaluating and comparing supply chain activities and performance. APICS SCC enables corporations, academic institutions and public sector organizations to address the ever-changing challenges of managing a global supply chain to elevate supply chain performance. APICS SCC is part of APICS, the premier professional association for supply chain and operations management.

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# COMPLEXITY THEORY, SENTIMENT AND SUPPLY CHAIN ORGANIZATIONAL BEHAVIOR

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COMPLEXITY THEORY, SENTIMENT AND SUPPLY CHAIN ORGANIZATIONAL BEHAVIOR
Introducing complexity theory in supply chain practice

Three “flows” form the core of supply chain operation—products (or services), information and finance. But, social relationships also move across the supply chain. As supply chain partners extend and withdraw trust and confidence, this social “flow” acts as a gatekeeper to the traditional three.

Supply chain management follows a set of rules defined by financial practices, contract terms and enterprise resources planning system logic. Yet standards, while useful, do not ensure success. Social relationships between suppliers, producers, distributors and customers—all of whom have their own needs, goals and strategies—create complexity within supply chains. This results in both insights and obstacles to meeting market needs.

Complicated versus complex supply chains

If supply chains were fully automated machines, then the flows of products (or services), information and finance would merely be complicated. Complicated systems have many moving parts that interact with each other in fixed or tightly defined and predictable ways. Should a breakdown occur, it is typically possible to make repairs by restoring the broken component. Examples of complicated systems are mechanical wristwatches or jet engines.

Some aspects of a supply chain, including fixed assets such as factories and warehouses and fixed (by law) practices of finance, behave like complicated systems. However, human behavior makes supply chains complex systems as well as complicated.

Complex systems also have many moving parts that interact, but these parts do not have fixed interactions and dependencies. In most supply chains, partners and stakeholders do not behave like gears in a machine. Their behavior and decision-making processes are not fixed. A change in relationships can produce subsequent changes in decisions, plans, trust and confidence that can produce effects elsewhere along the supply chain.

Regulating the operation of a complex system is usually more difficult than a complicated system. In an effort to control outcomes, supply chain professionals attempt to reduce complexity in favor of enhancing predictability. We develop contracts with set terms and conditions. We precisely measure time and distance to move products. We use information technology systems that are binary in their logic.

Still supply chains remain both complicated and complex. And because of complexity, supply chains are not fully predictable and behave in unexpected
A perfect supply chain on paper can quickly fail in actual practice, and for reasons that are not always clear. This raises the question: **Can we improve supply chain performance by better understanding the complexity introduced by human relationships?**

**Complexity theory and supply chain**

Complexity theory states, “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.”

Complexity theory was originally used to study diverse systems such as those found in theoretical physics, and later extended to social and ecological domains. Today, complexity theory is widely applied to everything from the modeling crowd movement to formulating advanced product strategy. Application to supply chains is a more recent extension.

Consistent with complexity theory, we can describe a supply chain as a system made of many independent actors that behave as a single unit. Each actor responds to changes in the environment just as a community member or market participant responds to changes in theirs. There is no single master of the supply chain. Rather, self-organization occurs without the command of any central controller, through cooperation and competition between the members of the system.

**Emergent supply chain behaviors: The outcome of complex supply chains**

Emergent supply chain behavior is unanticipated or unexpected behavior. Emergent behaviors often appear because of changing relationships and dependencies between people who operate the supply chain. Whether the changes are simple or profound, they impact the decisions, actions, and choices of supply chain partners. Even small changes over time may add up to significant unanticipated behavior challenging supply chain synchronization, planning, or partner relationships. A common example is the supply chain bullwhip effect, which the APICS Dictionary defines as:

> “An extreme change in the supply position upstream in a supply chain generated by a small change in demand downstream in the supply chain. Inventory can quickly move from being backordered to being excess. This is caused by the serial nature of communicating orders up the chain with the inherent transportation delays of moving product down the chain. The bullwhip effect can be eliminated by synchronizing the supply chain.”
Emergent behavior does not always have a negative impact on the supply chain. It may help the supply chain adapt to the pressures of markets, respond to opportunity and solve conflict. Emergent behavior can help the supply chain learn to adapt and remain relevant. Without it, the supply chain would likely become inflexible and obsolete.

Today’s supply chain professional must work to anticipate and effectively shape desirable outcomes. In short, he or she must thrive in complex systems and add value by working with and not against complexity. This calls for a combination of supply chain management and leadership, as well as insight in supply chain organizational behavior.

Complexity theory helps us to see the supply chain as an ever-changing system of human relationships and dependencies.

**Personal perspectives and perceptions**
Unlike objective supply chain metrics, processes, and practices, people:

- have hidden biases and often do not share the same perspective
- do not communicate all the information they possess
- have personal or team goals that may not align with organization and supply chain goals
- respond to real and perceived opportunities, pressures and changes
- are not aware of the large impact over time of small decisions they take.

**Normal business activity**
Supply chain partner businesses, as individual companies, continually engage in activities that result in changed relationships and dependencies, such as

- business reorganization, realignment or new leadership initiatives
- mergers, acquisitions, divestures and initial public offerings (IPOs)
- periods of high growth and expansion
- change management projects
- response to risk events
- significant changes in outsourcing, insourcing, reshoring.
**Weak relationships risk negative emergent behavior**

In supply chain ecosystems, weak partner relationships create a risk of quickly or quietly changing partner relationships and dependencies. This, in turn, can lead to unwanted emergent behavior in the supply chain.

Typical features of weak partner relationships are:

- transactional-only relationships
- persistent difficulty meeting customer or supplier expectations, such as location, price or logistics
- disagreement about who has more influence; clashing perceptions of dependency or clout
- lack of visibility, such as insufficient sharing of operational information, financial strength or current risks.

Under these conditions a partner may quietly change its relationship behavior, or may seek different partners giving lower priority to a firm. This behavior can result in emerging, unexpected behaviors in the supply chain. For example, the partner’s customary inventory and service levels may fall, creating stockouts that ripple through the supply chain. Critical information that would have been shared fails to appear. Broken expectations follow, leading to greater uncertainty and perceived risk. Uncertainty and risk cause relationship behavior changes in other supply chain partners that can add up to something negative and unexpected.

**Strong relationships encourage positive emergent behavior**

In contrast, strong relationships tend to remain stable even in the face of challenge. Relationship behaviors and dependencies do not change quickly or easily. Even under challenging conditions, reserves of goodwill maintain the relationship until improved conditions reappear.

Common features of strong partner relationships include:

- effective communication
- shared vision and strategy
- joint investments or shared risk-taking
- understanding of partners’ perspectives.
Positive emergent behaviors typically feature greater collaborative practices and can lead to reduced uncertainty, faster performance, and more information sharing. Examples can be as simple as timely reminders or volunteering of insightful information. They can be as complex as facilitation of key projects, research, and development goals, or new product development.

Supply chain managers and leaders need to anticipate the risk of negative emergent behaviors and respond when they appear. Supply chain managers and leaders also should encourage and reward positive emergent behaviors.

**Managing complexity and supply chain sentiment**

Complexity theory and supply chain organizational behavior are not limited to observation. It is possible to capture and measure pressure or dissatisfaction that may lead to changing relationship behaviors. While supply chain partner relationship management looks at individual partners and their organizations, there is a method to look at the state of relationships across the supply chain when viewed as a complex system. This approach is referred to as supply chain sentiment management.

**What is supply chain sentiment?**

Sentiment is enduring but not permanent attitudes toward partners and practices in a supply chain system. It is a tool for learning ways complexity and relationships may be changing, capturing human opinions, changing confidences and identifying perceived challenges and new variables among supply chain partners. These subjective perspectives act as gatekeepers to increasing or decreasing trust and confidence.

Ultimately, sentiment develops from comprehensive sets of experiences.

**Sentiment as a tool**

Supply chain sentiment is a useful planning and problem resolution tool. If two firms with well-aligned missions, visions and goals also respectively have well-aligned strategy and tactics, then each will likely see the other and the supply chain as a whole with good or positive sentiment.

Good sentiment creates stability and reliability that form the basis for long-term trust and confidence to develop—a foundation on which to build.

Poor or negative sentiment often serves to block flows of trust and confidence, and ultimately flows of goods, information and finance from...
one partner to the next.

For example, on Boeing 787 factory floors, different suppliers ended up working together directly, not just through Boeing. Boeing could vouch for one supplier on behalf of another, relying on each partner’s trust in Boeing. Vouching places Boeing at risk if one supplier fails to meet expectations, but the reward is a faster than arms-length engagement between suppliers.

These behaviors change how relationships work and the levels of dependency in the supply chain. This is why tracking sentiment is effective at managing supply chain complexity and emerging behaviors.

**Developing a sentiment index**

Sentiment management targets primary (or tier 1) suppliers first, otherwise it can become excessively complex and unfocused. These suppliers and partners are critical to business, hard to replace or may require long lead times.

With non-primary suppliers (tier 2 or tier 3), uncertainty is more tolerable as these suppliers are easily replicable. For example, they supply non-critical items, such as those with short lead times and plentiful supply. Or intensive tracking of the inventory or service levels they supply is not essential or cost effective.

Measuring sentiment starts with developing a simple, short and anonymous online survey for all primary ecosystem partners. Create questions to measure a qualitative sentiment level or trend by giving numeric values to a range of feelings from strongly disagree to strongly agree or very poor to ideal. Questions should probe for potential relationship changing situations or pressures.

Example topics include:

- current business conditions
- expected business conditions for the next six months
- satisfaction with current supply chain partner relationships
- flow of products or services, information, finance and feedback from supply chain partners
- investment in new opportunities, markets, customers or capital facilities and equipment.
Example questions might include:

- I know what the supply chain expects of me, and I know how I make an important difference upstream and downstream.
- I know how my work and the supply chain’s work serves my organization’s strategy, tactics, goals, objectives.
- I know how my organization fits our partner’s strategy, tactics, goals and objectives.
- I know where my performance, my organization’s performance and the supply chain’s performance stand—both from objective key performance indicators and from a subjective sentiment perspective.

Average all questions to form a supply chain sentiment index. Compare this average to previous results to see trends. This makes it easy to see whether current conditions or sentiment management practices are having a desirable effect. Implement a regular survey schedule—once a quarter, once a year or however often is most appropriate.

**Evaluating sentiment**

Sentiment values predict future behavior. Strong positive sentiment opens the gates to greater trust and confidence and allows greater flow of product, service and financial information along the supply chain. Strong negative sentiment reduces trust and confidence, and reduces the supply chain flows of product, service and financial information.

Sentiment level is a strategic competitive advantage as high levels of confidence, trust and expectation enable supply chain agglomeration—closely aligned in strategy and goals, with less need for risk-protection measures. This ensures faster performance and greater willingness to share risk and reward, provide insight and act on opportunities on behalf of the supply chain.
Sentiment variation across the supply chain ecosystem

Even when objective measurements of partner relationships remain healthy, variation in human relationships exist. Subjective individual perspectives may cause individuals to change sentiment, and behave and make decisions in unexpected ways. Drivers of perspective, which may lack visibility, include:

Personal risk sensitivity. Supply chain professionals look for patterns across both the short term and long term. People have memories of past relationships and may wonder if good or bad experience may return. For example, an off-hand comment, a minor deviation from routine behavior or a reduction in informal communication from one partner may cause another to see a combined deeper meaning leading to greater risk in the relationship.

Cognitive bias. The human mind brings inaccurate cognitive biases as filters to complexity and relationships. Bias creates a tendency to make decisions and take action based on limited information, self-interest, overconfidence or attachment to past experience. This can result in distortion in perception, illogical interpretation, inaccurate judgments and bad decisions. Hindsight bias, confirmation bias or cultural bias can be a factor.

Positive and negative feedback conflict. Negative feedback seeks equilibrium, or an optimal balance between opposites. A simple example is a home thermostat. If the temperature is falling, the thermostat triggers heat to cause the temperature to move in the opposite direction. Positive feedback calls for amplifying the current direction. An example is a stock market bubble. If stock prices rise, investor interest in stocks increases. Investors increase demand for stock, causing stock prices to rise further. This can, however, lead to a bubble burst.

Conflict between positive and negative feedback may appear in times of unexpected, growing demand. Even commodities such as cement or lumber may see a positive and negative feedback conflict if a housing bubble appears. Construction of new homes will drive cement and lumber prices beyond historic equilibrium, only to eventually collapse when the housing bubble collapses. But before the collapse a supply chain stakeholder may seek to maximize revenue by increasing production and sales. Others may not believe a bubble has formed and expect the market has reached a new normal.

Dissimilar goodwill. Good relationships over time create goodwill for partners. Goodwill is the justification to continue normal relationships even in times of reduced performance or conflict. However, each human being can price goodwill deposits and withdrawals differently. Positive sentiment levels
generate more stored goodwill and require less withdrawal of goodwill to maintain a relationship encountering difficulty. In contrast, low sentiment levels create less stored goodwill and require more goodwill withdrawal to maintain a challenged relationship.

Gaps or differences in sentiment are common in complex relationships and across supply chains. A supply chain professional should develop partner relationships sufficiently strong enough to make drivers of subjective perspectives more visible and expressible. Failure to do so may result in unnoticed and unexpected partner changes to sentiment and relationships and in greater supply chain complexity and negative emergent behaviors.

**Conclusion**

Human perspective and relationships are sometimes insufficiently visible in supply chain management. It is easy to see a supply chain as an objective system of resources, such as factories, products and finance flows. It is harder to see a supply chain as a subjective system of human partner perspectives and sentiment. Nonetheless, the human component is critical to supply chain success.

Supply chains are both complicated and complex. Complicated systems such as engines and machines are ultimately objective in their behavior. Their many moving parts cannot individually change associations with any other moving part. This is true of supply chains in terms of products, information and finance. However, supply chains also are complex. This is because supply chain partners, unlike parts in machines, can change the nature of their relationships to others in the supply chain. They can change their dependencies on others and adjust behavior toward other partners. This can lead to emergent behaviors, both good and bad.

Effective supply chain professionals watch for potential causes of changing relationships. Capturing supply chain sentiment on a regular basis can offer early warnings of this potential and allow for follow-up with partners, and analysis of potential impact to supply chain performance.

The study of supply chains and complexity theory is in its early stages, but it is likely to assist in creating greater clarity to the field of supply chain management. Supply chain excellence depends not only on the physical resources of the supply chain, but the sentiment and relationship of the individuals in alignment with optimal performance.
SOURCES

- What Drives Supply Chain Behavior?, hbswk.hbs.edu/item/4170.html
- Thriving in Complexity: Ten Principles for Leaders in the Coming Age, www.jblearning.com/samples/0763744603/44603_ch02_final.pdf
ADDITIONAL RESOURCES
For more information about complexity theory and organizations

Organizations and resources:
- The Santa Fe Institute, www.santafe.edu
- New England Complex Systems Institute, necsi.edu
- Complexity Digest, comdig.unam.mx
- The London School of Economics and Political Science (LSE) Complexity Group, www.lse.ac.uk/researchAndExpertise/units/complexity/home.aspx

Books on complexity:

More on cognitive bias:
- www.psychologytoday.com/blog/the-power-prime/201305/cognitive-biases-are-bad-business

What areas of the APICS Operations Management Body of Knowledge Framework does this report serve?
- 3.2 Supply chain visibility, synchronization, and bullwhip minimization
- 3.10 Customer relationship management (CRM)
- 7.1 Project organization and leadership
- 9.3 Virtual team collaboration
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