The Case for Applying Systems Thinking to Global Supply Chain Management

by

Daniel L. Gardner

Abstract

"Systems Thinking" is an engineering discipline that is designed to improve the performance of any type of system by leveraging the interactions that take place between its component parts. Because it focuses on the interdependencies that exist amongst the elements that comprise a system's structure, as well as the feedback loops that occur within it, Systems Thinking is ideal for application to the field of supply chain management. Whereas the principles of Systems Thinking can be seen in supply chain simulations like "The Beer Game", its use has not kept up with the complexities inherent to globalization. It is the objective of this paper to re-introduce Systems Thinking to global trade professionals and demonstrate how the application of its tenets to supply chain management can yield order-of-magnitude advances in operational outcomes, supplier relations, customer satisfaction, corporate citizenship and financial results.

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Introduction

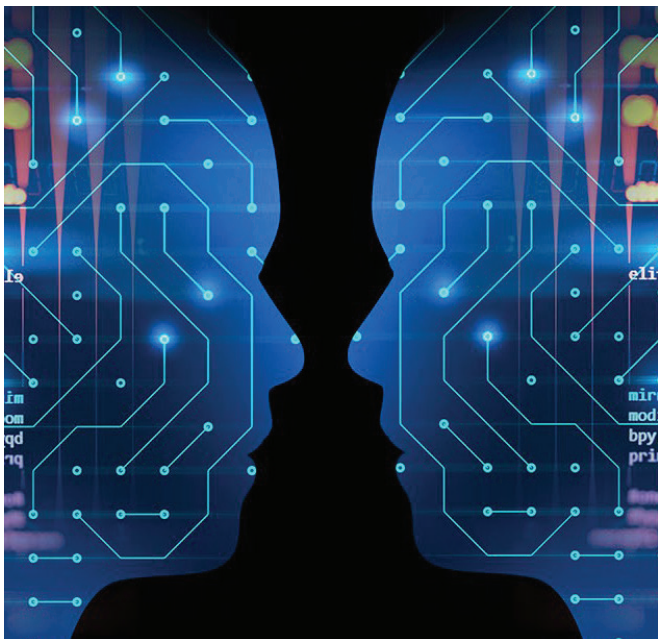
Over the last seventy five years the field of Business Management has gone through its fair share of company-saving techniques and fads. Starting with the Total Quality Management movement of the 1950's, and moving on to methodologies that include Management By Objectives, Reengineering and Lean Six Sigma, there's been no shortage of sure-fire paths to organizational success. While many of these schools have considerable merit, they've all had their "fifteen minutes of fame", each lasting just long enough for some high-priced consultancy to conjure up a new variation on a similar theme.

To the detriment of mankind in general, and certainly in the field of business, it seems that the discipline known as "Systems Thinking" has succumb to such a fate. Born in the 1930's at the Massachusetts Institute of Technology, Systems Thinking was founded on the premise that when working to improve a system's performance, one cannot focus solely on the cause and effect relationships that go on between its individual parts. Instead, Systems Thinkers are trained to identify and leverage the feedback loops that impact ALL elements of a system. With outcomes that are separated by space and time, it is the extent to which organizations can harness the power of these feedback loops that determines a system's performance.

Even with such a truncated definition, one can see that there is a technical, as well as common sense appeal to Systems Thinking. In spite of this natural attraction and the benefits it can bring to many fields of human endeavor, Systems Thinking gradually lost its luster. Although it hit a peak in the early seventies with the seminal book, *The Limits to Growth* and enjoyed a brief Renaissance in the nineties on the back of another important work, *The Fifth Discipline*, Systems Thinking has faded from mainstream consciousness.

When it comes to industrial or commercial applications, the fact that Systems Thinking has been relegated to obscurity in no way diminishes the power of its underlying philosophy. To the contrary, the complexities inherent to the globalization of trade demand that a "new" approach be taken…an approach that views global supply chains as interconnected systems of goal-seeking actors whose interactions produce any number of operational, financial, environmental and social outcomes.

While there is nothing new about Systems Thinking, it is the goal of this paper to demonstrate that when adopted as a foundational component of a company's culture, and empowered by Artificial Intelligence, Systems Thinking will not only transform the organization itself, but improve the world in which it operates.



Systems Thinking: Background & Key Milestones

Ironically, one of the greatest strengths of Systems Thinking is what probably contributed to its lack of adoption: the use of mathematical models to solve complex problems. Bearing in mind that Systems Thinking can be traced to the Electrical Engineering department at MIT, its first applications were used to solve multi-variate equations in fields such as the design of power grids and surface-to-air defense systems. Of no small historical significance, it was in 1931 that Professor Vannevar Bush invented an electro-mechanical device to solve these complex equations, the "Differential Analyzer". Not only did this invention lay the groundwork for what became Systems Thinking, it contributed to the design structure of the first computers.

As demonstrated in Figure 1, Systems Thinking has a rich history of superstars and milestones. With that said, and while acknowledging the long list of people that contributed to its development, the patron saint of Systems Thinking was another MIT professor, Jay W. Forrester. Not only did Dr. Forrester expand what he called, "System Dynamics" to industrial, environmental and social constructs, he eloquently explained why the human mind has difficulty in understanding the complexity of a system…

"The human mind is excellent in its ability to observe the elementary forces and actions of which a system is composed. The human

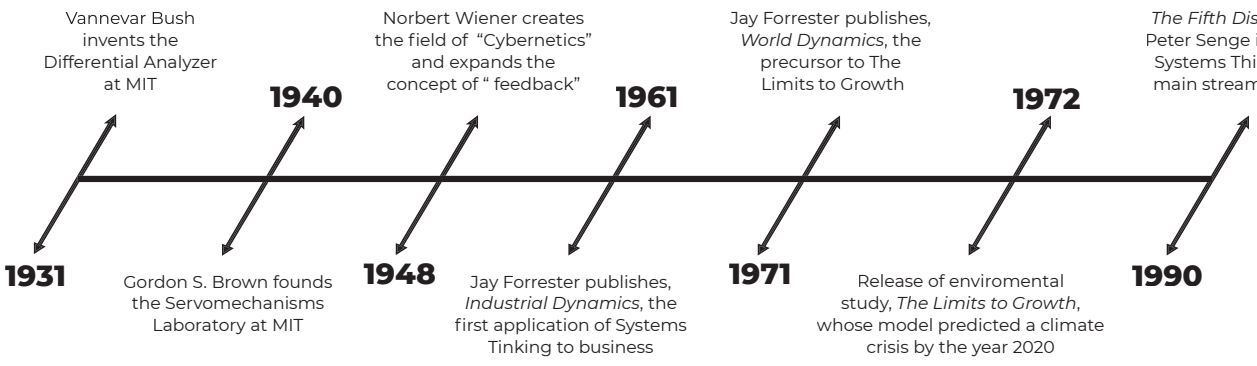


Figure 1: A Timeline of Systems Thinking Milestones

mind is effective in identifying the structure of a complex situation. But human experience trains the mind only poorly for estimating the dynamic consequences of how the parts of a system will interact with one another."[1]

Based on the above observation, Jay Forrester inspired what became the pinnacle of Systems Thinking, the environmental impact study detailed in the 1972 report, *The Limits to Growth*. Conducted by the academic team of Dennis and Donella Meadows, the project used the modeling tools developed by Dr. Forrester to demonstrate how the feedback mechanisms that exist between large-scale agriculture, population growth, industrialization, natural resource consumption and pollution would lead to a worldwide environmental crisis. Now known as, "Climate Change", it is instructive to note that based on their modeling, the Meadows team predicted that Mother Earth would reach a point of acute damage by the year 2020.

For purposes of applying Systems Thinking to supply chain management, it is very important to mention the contributions of Peter M. Senge. Through his work at MIT and as expressed in his book, *The Fifth Discipline*, Dr. Senge expanded the frontiers of Systems Thinking by demonstrating how both individuals and companies can benefit from its founding principles. By changing one's "Mental Model", (perceptions and assumptions about the world around us), Senge states that the adoption of the Systems Thinking philosophy can change a person's life. When embraced by an organization, Senge also believes that Systems Thinking leads to a virtuous cycle that transforms businesses into what he called a, "Learning Organization".

At the end of the day, a supply chain is a system whose participants are separated by space, time and more often than not, by conflicting objectives. In spite of their ever-changing nature, most supply chains are treated as just that…a series of individual links in a chain that can't see beyond the cause and effect dynamic between the links they're connected to. When a supply chain system is treated in a linear fashion, it is inevitable that the policies, decisions and actions taken by one player in the chain will surface to create unintended consequences for many others. In order to avoid this phenomenon, a much more circular approach must be taken. As described in the upcoming Section, that approach is based on two very important principles.

Two Core Principles of Systems Thinking

There is no doubt that the transition from a linear, to a circular approach to understanding and influencing systemic behavior requires a change to existing mental models. That journey begins with an individual's personal buy-in to the Systems Thinking discipline, and culminates in the creation of a Learning Organization that harnesses human intelligence to create breakthrough results. In other words, when people really start believing that, "*What goes around, really does come around*", great results can be achieved.

At an individual level, the first step in becoming a Systems Thinker is to train one's mind to look beyond the linear cause and effect scenarios that transpire between the parts of a system, and to identify the circular, interdependent goings-on amongst all variables in that system. When individuals and (eventually) groups of people adopt this circular approach to thinking, the culture of an organization changes, and Systems Thinking becomes a way of life. Such was the case with the team of scientists, engineers, sociologists and demographers that produced the magnum opus of Systems Thinking, *The Limits to Growth*.

As noted earlier, the results of the study published in, *The Limits to Growth* became the cornerstone of what evolved into the Climate Change movement. In it, a diverse team led by Dennis and Donella Meadows

described the inevitable consequences of unfettered growth in agriculture, population, industrialization, natural resource consumption and pollution. Although the mathematical models inspired by Jay Forrester were essential to the study, the underlying philosophy that encourages a more holistic mindset can be felt throughout the work, as well. In fact, one can see how the Meadows team manifested this philosophy when explaining why past efforts to understand man's impact on Mother Earth had failed:

"This failure occurs in large part because we continue to examine single items in the problematique without understanding that the whole is more than the sum of the parts, that change in one element means changes in the others."[2]

The Meadows' project differed from previous efforts because instead of isolating cause and effect dynamics that are linked in space in time (e.g. agricultural output leads to population growth), they looked at how activities in one element of the system changed behavior in all of the others. As one example, they went beyond the linear dynamic of food supply → population growth to consider factors like the impact of increased birth rates on a finite amount of arable and/or habitable land, the depletion of raw materials used to manufacture the goods needed to satisfy an ever-expanding population, and how all of that drove not only pollution, but Climate Change. Basically, and as shown in Figure 2, the breakthrough came when the Meadows team eschewed a linear approach and became holistic Systems Thinkers.

Admittedly simplistic at first glance, the shift from linear to circular thinking prepares the human mind to embrace what is, without question, the most important requirement of Systems Thinking: Understanding the dynamics inherent to feedback loops.

For most business people, when we think of the word "feedback" we associate its meaning with the input someone receives from colleagues after making a PowerPoint presentation. While certainly an accurate definition, it should be noted that the term "feedback" took on a different meaning in the 1948 book, "Cybernetics", when Harvard professor Norbert Wiener drew a parallel between the problems associated with designing electrical circuitry, and the communication challenges that humans experience in complex organizations.

It's no coincidence that terms like "amplification", "distortion", "noise" and ultimately, "feedback" were first used in the labs of engineers and mathematicians like Gordon S. Brown and Norbert Wiener.

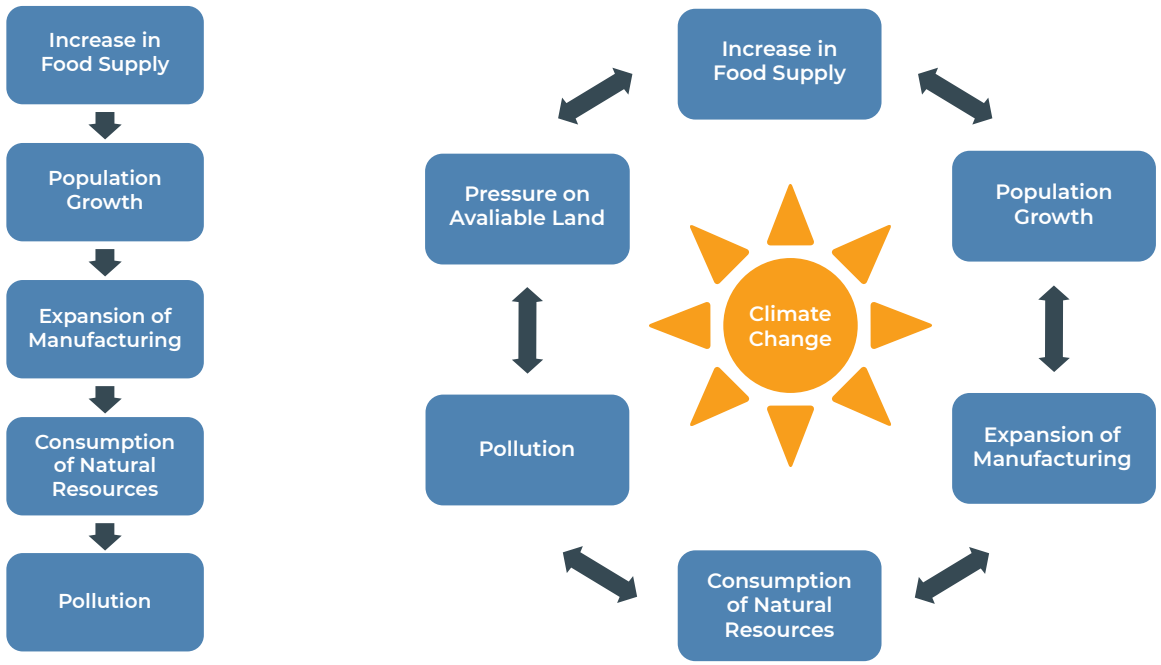


Figure 2: Climate Change and the Shift from Linear to Circular Thinking

Especially relevant in the early days of computer design, it was Wiener who discovered that the design, performance and ultimately, the electrical feedback generated between switches, relays and circuits had a profound impact on the behavior of the entire device. As a bi-product of his work, Dr. Wiener applied the principle of feedback loops to human interactions and established the field of Cybernetics.

Found in any area of human endeavor where interacting elements are present, feedback loops take shape when the result of an action in one part of a system becomes input for other parts of the same system. In other words, within any type of environment there are very few cause and effect relationships with an easily identifiable beginning and end. The reality is that the result of a single interaction not only "feeds back" to the source of the original action (thus altering future actions taken by the source itself), it impacts other parts of the environment, which in turn influence actions taken by those elements.

In what became known as an, "Information Feedback System", this never-ending process leads to a cycle of new results, decisions and actions, which in turn keeps the system in a state of perpetual motion.

Supply Chains as Information Feedback Systems: Two Key Types of Feedback Loops

If the concepts and principles that have been discussed thus far seem to describe an international supply chain, it's because they do. Based on this alignment, we can begin the process of changing our mental models to envision a supply chain for what it really is: A complex Information Feedback System that's made up of arm's length players whose objectives, policies, decisions and actions keep the system in a constant state of flux. In order to make this mental shift permanent, it is essential that we be able to understand the dynamics behind two types of feedback loops found in any global operation.

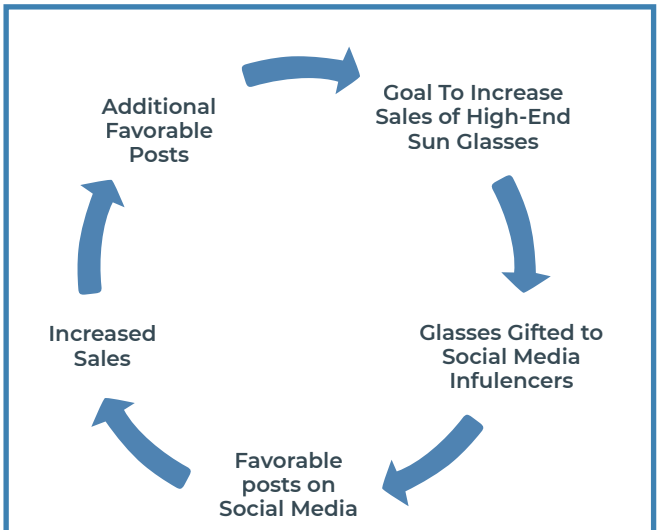


Figure 3: A Virtuous Sales Cycle of Social Media Influencers and Increased Sales

While recognizing that there are a number of different kinds of feedback loops, the two that are most endemic to international business are known as "Reinforcing" and "Balancing". When represented as a circular pattern of behavior between system elements, a breakdown of these two types of feedback loops can uncover opportunities for adjustments and improvement that may not be visible under a more linear, cause and effect analysis.

Also known as an "Amplifying Feedback Loop", the first point to be made about Reinforcing Feedback Loops is that they exist in systems where either growth or decline are occurring. Depending on the circumstances, growth or decline may be viewed as a positive or a negative; or what is more commonly referred to in Systems Thinking as a "virtuous" or a "vicious" cycle. In the former instance, the elements of the system engage in circular behavior that reinforces a desired outcome, while in the case of the latter, reinforcing interactions drive results that are not only unwanted, but often times unexpected. A pair of examples will illustrate these points.

A very basic example of a Reinforcing Feedback Loop can be seen in Figure 3 where the owners of a newly launched brand of premium priced sun glasses has jumpstarted sales by gifting products to social media fashion influencers. The virtuous cycle kicks in when influencers like the sun glasses, post positive reviews and sales start ticking upwards. Of course, the cycle will only continue as long as paying customers acquire the product, post their own reviews and not only continue buying themselves, but inspire others to do so, too.

It is very important to point out that in this scenario, the virtuous cycle of sales growth was driven by the intentional act of gifting sunglasses to social media influencers. The sun glass company made a strategic marketing decision, planned accordingly and executed well. As we'll see in the upcoming example, a misinterpretation of unidentified demand can lead to a very different outcome.

In looking at an example of a Reinforcing Feedback Loop that results in a vicious cycle, we're going to draw on the classic supply chain simulation known as, "The Beer Game". Briefly mentioned in the Abstract of this paper, The Beer Game is a cautionary tale of inventory management that was first described by Jay Forrester in his 1961 book, *Industrial Dynamics*. Now played by thousands of students and business people around the world, the simulation portrays an inevitable pattern of out-of-control inventory growth between a liquor store retailer, a beer wholesaler and a brewery.

Although The Beer Game has been around for sixty years and there's a big difference between a small domestic supply chain and a multi-player global operation, the feedback loop that triggers a vicious cycle of inventory growth is as powerful today as it was back in 1961. And that's because The Beer Game illustrates how inventories go off the rails when an unexplained increase in product demand and a lack of communication converge with time lags, blind spots and backorders to create what is known as the "Bullwhip Effect".

> Based on this alignment, we can begin the process of changing our mental models to envision a supply chain for what it really is: A complex Information Feedback System that's made up of arm's length players whose objectives, policies, decisions and actions keep the system in a constant state of flux.

The Beer Game: Version 2021

In an updated version of The Beer Game, a local liquor store owner notices a substantial increase in sales of a craft beer she started carrying a few months back. This goes on for a couple of weeks and without ever asking her customers why they were buying more of this brew, when the sales representative from the store owner's beer distributor comes in to take the weekly order, she orders three times more than usual. When the sales rep informs the owner that other liquor stores are stocking up on this brand, too, she orders even more.

For this particular beer, there is a four week lead time, so the liquor store owner won't actually see the additional inventory for a month. That's because the beer distributor needs time to replenish their own inventory by ordering from the brewery. Given that the beer distributor is receiving larger orders for this beer from multiple liquor stores, their orders on the brewery go up commensurately. In turn, the brewer starts to get overwhelmed with orders, can't meet demand because they're a small craft brewery, and has to start issuing backorders to the distributor for all future liquor store deliveries.

During the first two weeks of the four week lead time, the liquor store owner continues to experience high demand for the craft beer and sells out the quantities she had been ordering prior to the spike in demand. Even though orders on the brewery have now been backordered by the distributor, in a panic the liquor store owner not only orders more from her main supplier, she starts placing orders for the craft beer on distributors outside of her geographic area. Although no one in the supply chain really understands what's going on, it is the amplification of unexplained demand that sets the vicious cycle in motion.

What nobody knew (except the actual buyers of the craft beer) was that the demand surge was due to a shout-out the beer got in a YouTube video from a local rock band. As the video cooled off, so did beer sales, settling at a point a bit higher than its historical levels. Unfortunately, the real problem surfaced when all of the backordered beer started showing up just as consumption flattened. Inevitably, everyone in the supply chain got stuck with unwanted inventory that took ages to sell, at a discounted price.

The vicious cycle revealed by The Beer Game can be visualized in Figure 4, where the (blue) clockwise cycle represents the amplification of misinterpreted demand and the (red) counterclockwise cycle shows how assumptions, overreactions and time delays lead to inventory bloat.

For all of its simplicity, The Beer Game exposes a number of dynamics that are anathema to Systems Thinking. Essentially an exercise in assumption-based decision making, the genesis of the run-away inventory can be traced to a lack of understanding of the source of increased demand. Because neither the liquor store owner, beer distributor nor brewer took the time to collaboratively understand their supply chain, each assumed that the solution was to order/produce more beer. Early in the cycle, panic buying from multiple liquor stores exacerbated the problem, sending amplified demand signals up the chain. And from there, long lead times and production delays put the icing on what turned out to be a very expensive cake.

As shown in Figure 5, it is precisely this amplification of demand signals that creates the aforementioned Bullwhip Effect.

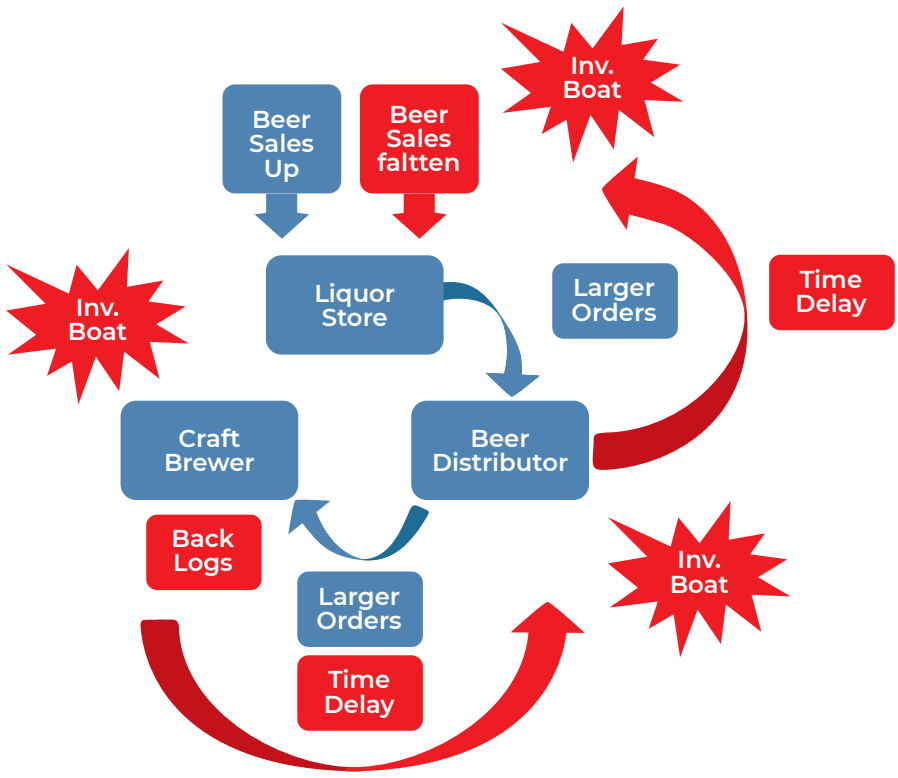
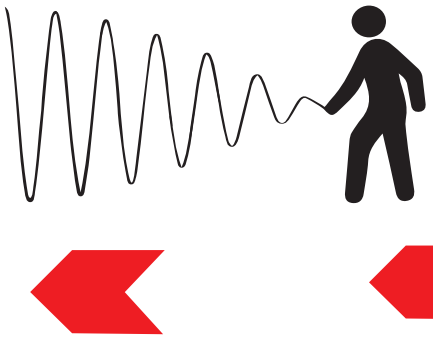


Figure 4: A Vicious Cycle (Reinforcing Feedback Loop) of Inventory Bloat



Amplified demand quantities created by the retailer, beer distributor and craft brewery

Actual product demand

Figure 5: The Amplification of Misunderstood Demand Signals and The Bullwhip Effect

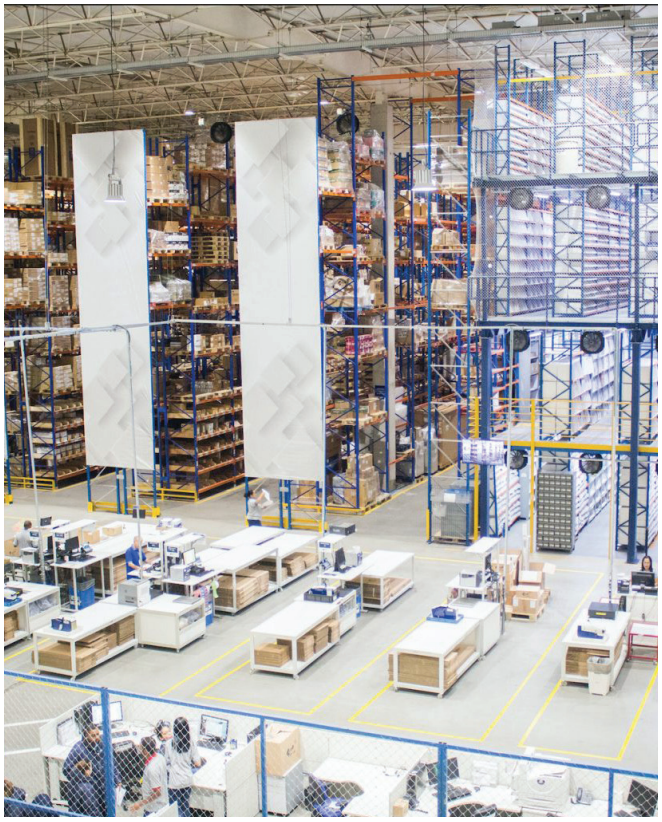
The Supply Chain Version of Balancing Feedback Loops

Without question, the transition towards treating a supply chain as an Information Feedback System must be founded on an understanding of both types of Reinforcing Feedback Loops (virtuous and vicious). Equally important, however, is the ability to detect the second type of loop that is found in all global supply chains, the Balancing Feedback Loop. As we'll see in the rest of this Section, this loop surfaces in situations where an objective must be achieved or a "problem" has to be solved. Usually tied to some sort of financial metric or operational Key Performance Indicator (KPI), the decisions made in scenarios where Balancing Feedback Loops are afoot sometimes do more harm than good.

Peter Senge does an excellent job of describing a Balancing Feedback Loop in, *The Fifth Discipline* when he says, "A balancing process is always operating to reduce a gap between what is desired and what exists… and the balancing process continues to reach the goal, even if the target is moving."[3] For purposes of global business operations, the operative excerpt from Dr. Senge's definition is undoubtedly, "reducing a gap between what is desired and what exists".

When you think about it, this phrase encapsulates what people do every day in a multitude of supply chain situations. For example, companies are constantly working to compress the gap between the scheduled time-to-market for a new product launch and how long it really takes, or trying to reduce the gap between an item's budgeted landed cost and what the true expense is, or closing the gap between targeted inventory levels and what's on a company's balance sheet. In a world that is governed by quarterly earnings and short term goals, it's easy to see why there are dozens of Balancing Feedback Loops in even the most basic of supply chains.

Balancing Feedback Loops can be especially pernicious because they are often times enabled by a well-intentioned policy or decision. Of particular interest is a phenomenon where an action that is taken in one part of a supply chain might "fix" a problem or achieve a goal, but it ends up creating a new issue somewhere else. What makes this scenario even more tenuous is that there is always a, "countervailing force" pushing against the original action, the identity of which won't be revealed until well after the fact. An example will help to illustrate how a Balancing Feedback Loop creates all sorts of mischief in places one might never envision.



The Case of Valentina's Fashion House

Located in the Fashion District of Los Angeles, a company that we'll call "Valentina's Fashion House" (VFH) imports bargain-priced blue jeans from manufacturers in China, that they then sell in large quantities to retailers and e-commerce firms around the country. Although Chinese jeans had historically carried a hefty customs duty in the U.S. (17%), the low unit cost more than offset import duties and profit margins were always good. Unfortunately, jeans became subject to the Trump Tariffs in 2018, which tacked an extra 25% in duties on to the original duty rate for jeans. The result of this circumstance was that VFH's per unit landed cost went up by 25%, the expense of which was difficult to pass on to their price sensitive customers.

In what should be recognized as a linear cause and effect reaction, the executives at Valentina's Fashion House (understandably) came to the conclusion that China was no longer viable for jeans, and undertook an initiative to import from smaller vendors in Indonesia. In the words of Peter Senge, the goal was to "close the gap" between the new landed cost brought on by the Trump Tariffs and the landed cost they thought they could secure elsewhere. Stated differently, this company wanted to get back to the profit margins they had enjoyed prior to the additional duties. Quite predictably, there were Balancing Feedback Loops and countervailing forces in play that sub-optimized VFH's "solution" to its gross margin problem.

Indonesia seemed like a viable option because although the standard duty rate on jeans was the same as China (17%), there were no additional Trump Tariffs. Even more attractive was the fact that Valentina's VP of Sourcing was able to negotiate unit cost pricing from the Indonesian vendors that was slightly lower than what they were paying in China. From a pure landed cost and profit margin perspective, things were looking good for the team at VFH. That is, until the countervailing forces found in all Balancing Feedback Loops started to chip away at what originally seemed like a solid strategic decision.

It's important to point out that in the lexicon of Systems Thinking, a countervailing force isn't necessarily a person or entity that is acting maliciously in response to a decision or action (although in global trade, it certainly could be!). More often than not, a countervailing force is a characteristic of an element in the system that by its very nature, pushes back against an original action. As noted, there is also a time delay from the moment an action is taken until the results of the push back surface. To make matters worse and depending on the loop, the consequences of the countervailing force can surface in other parts of the system. As we'll see in a moment, that's precisely what happened to Valentina's Fashion House.

From the outset, there were two time lags tied to the Balancing Feedback Loop in the sourcing element of this supply chain. First, due to the long lead times associated with purchasing goods in Indonesia, merchandise ordered from the new vendors wouldn't arrive to the U.S. until four months after the first orders were placed. Second, even after the goods arrived to the U.S., countervailing forces on the customer side of VFH's supply chain would have even more time to seep into both the financial and operational sub-systems of the operation.

One of the more impactful Balancing Feedback Loops in this case can be found in the overall nature of sourcing goods in Asia. As a general rule, the majority of product

manufacturers in Asia sell under what is known as a, “Build-to-Order” model. As the name implies, overseas suppliers do not carry finished goods inventory and only go into production when they receive a purchase order, along with a down payment, from the buyer. From there, the supplier uses the down payment to procure raw materials and go into production. Normally, another payment is required upon proof of export and the balance will be due upon arrival of goods to the U.S.

Valentina’s Fashion House had been working on this basis for years with its suppliers in China, but when they started placing large purchase orders on the Indonesian vendors, those suppliers quickly realized that their own raw materials vendors wanted more up-front money from them and as a result, had to ask Valentina’s for a larger initial down payment. So, right out of the gate, VFH’s finance department began to see a depletion of working capital.

Another countervailing force that debilitated VFH was that they were working with smaller factories that didn’t have the production capacity to cover the orders. So, whereas they previously worked with five factories in the highly concentrated Guangzhou area of S. China, they were now working with ten plants. Not only were they sending down payments to more factories in larger amounts, the new plants had quality issues that added weeks to the agreed upon lead times. When jeans were finally shipped, orders had to be air freighted to meet VFH’s delivery commitments to customers, with nearly a five-fold increase in transportation costs.

The preferred mode of international transportation for apparel importers is via container ship. That was the case for VFH, but there was another Balancing Feedback Loop in play, this time hobbling their logistics efforts. Normally, the transit time for maritime transport from Indonesia to the West Coast is twice that of China (30 vs. 15 days). Also, vessel sailings from China to the U.S. are direct port calls, whereas containers from SE Asia are trans-shipped via ports like Singapore. Much like a traveler missing a connecting flight, port congestion created a situation where VFH’s containers were being “rolled” (bumped off the “connecting flight”), thus creating uncertainty around when the containers would actually arrive to the U.S.

Although Valentina’s Fashion House was experiencing problems long before containers were loaded on a vessel, the unreliability of on-the-water transit times added insult to injury. Essentially, the confluence of inadequate production capacity, quality issues and unstable lead times created a level of variability in the supply chain that disrupted the flow of inventory. To compensate for that variability, VFH actually placed more orders on the Indonesian factories, creating a vicious cycle of inventory bloat, much like what we saw in The Beer Game.

While all of this was going on, and in spite of their paying exorbitant amounts in air freight, Valentina’s large customers started to either short-pay invoices due to late deliveries and/or poor quality, or they cancelled orders entirely. Now stuck with inventory that cost more to source in Indonesia than in China, Valentina’s Fashion House had to discount the price of the Indonesian jeans to get rid of them, and beg their original Chinese vendors to take them back. In order to appease those suppliers, VFH agreed to an increase in unit cost that was the final insult in an exercise that was doomed from Day One.

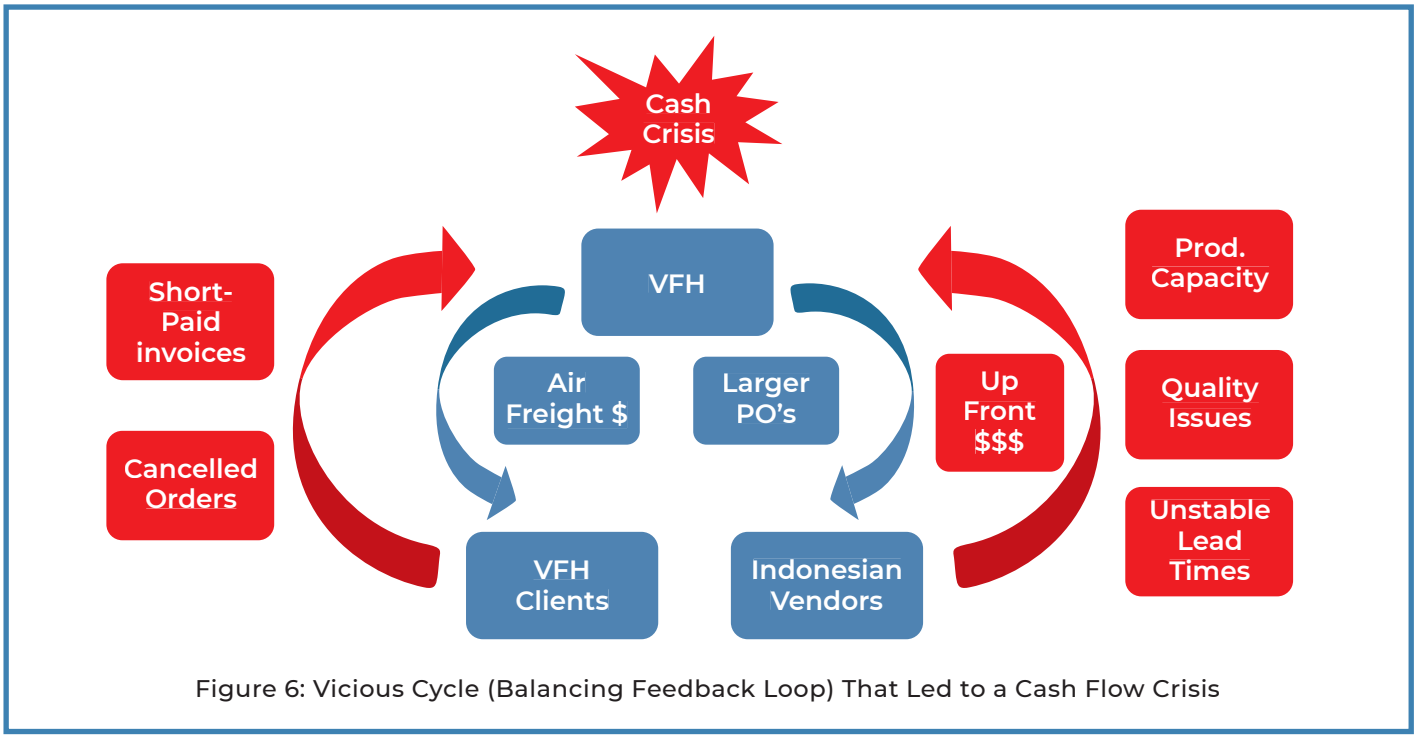


Figure 6: Vicious Cycle (Balancing Feedback Loop) That Led to a Cash Flow Crisis

As shown in Figure 6, the unintended consequences unleashed by Balancing Feedback Loops surface in areas that really are separated in time and space from an original action. In this instance, VFH's singular goal of maintaining gross margins caused them to overlook basic considerations like production capacity, product quality and extended lead times. While the management of Valentina's Fashion House was guilty of too many assumptions and mental models that impeded their due diligence, it would have been difficult for anyone to anticipate VFH's real existential problem: Depleted working capital that nearly put them out of business.

In the case of VFH, let's recall that the first sign of trouble arose when their new vendors started asking for larger down payments, which put pressure on cash flow. Also, quality issues and delays compelled them to ship via air freight, which more than quadrupled transportation expense. Finally, clients were discounting or cancelling orders, which meant less money was coming in. As any business person knows, when outlays exceed revenue, it won't take long to run out of cash. That's what nearly happened to VFH and they had to secure high interest loans to cover the shortfall. All in all, it took two years to get back to their original starting point.

Pitfalls of Linear, Cause & Effect Supply Chain Decision Making

As articulated in earlier quotes from Jay Forrester and Donella Meadows, the issue with linear thinking lies in a fixation on individual elements of a system, as opposed to taking a holistic view of how all variables interact with one another. In the case of Valentina's Fashion House, it was a focus on landed cost that caused the management team to ignore how their sourcing shift would impact (and be impacted by) other elements of the supply chain.

In retrospect, and long before the countervailing forces inherent to the new system surfaced, it was the management team's mental models that set them up for failure. Recalling that VFH had only bought jeans in China prior to the sourcing change, the mental models they used when evaluating the Indonesian option were heavily influenced by that skewed mindset. Instead of gaining a deep understanding of all of the elements of what was an entirely different system, VFH relied on prior experience, abstracts and assumptions to guide their decision making.

Although painful for VFH, their thought process should not be considered an anomaly. In fact, it was many years ago that the creators of Systems Thinking identified several linear thinking traps that VFH fell into. As a key step in the journey towards treating a supply chain as an Information Feedback System, decision makers should be aware of those pitfalls and as such, try to avoid them. In an effort to encapsulate much of what's been discussed thus far, below are three recurring phenomena that executives and supply chain operators must be leery of:

Conflicting Goals Sub-Optimize System Performance:

Regardless of the number of players in a given supply chain, there will always be conflicting goals. With each party's profit motive front and center, as well as clashes on matters as diverse as product engineering, unit cost, credit terms and logistics strategies, there's just no end to the potential conflicts that left untreated, will sub-optimize a system's overall performance.

In addition to the conflicts and countervailing forces that go on between arm's length supply chain actors, it's important to be aware of similar dynamics that exist amongst functional areas within the same company. Classic examples include disagreements between marketing and manufacturing on how many different items to produce, or an impasse with sourcing and purchasing on what suppliers to work with. The nature of the friction notwithstanding, internal conflicts can sometimes be worse than external ones.

"Quick Fixes" Can Create Unintended Consequences:

Practitioners of supply chain management love to be "proactive" and apply a, "*Get 'er done*" attitude to every issue that comes their way. However, and in spite of people's sincere efforts, quick fixes that are disguised as solutions almost always create unintended consequences. Ironically, as people work increasingly harder to fix new problems (i.e. push harder against the system), they're efforts turn into an endless game of Whack-a-Mole that only serves to destabilize the system even more.

Time and Space Don't Know Their Place:

As if unintended consequences weren't bad enough, complex systems behave in a way that unpleasant surprises only seem to appear well after the fact, and in places that even the sharpest of executives would never have considered. With over a dozen participants in the most basic of global supply chains, most of whom really are separated by geography, time zones, language and custom, it's no wonder that it takes weeks (or months) for an issue in one aspect of an operation to create havoc in another.

Systems Thinking for Supply Chain Professionals: Core Requirements & Best Practices

When you really think about it, supply chain management comes down to predicting the future and placing bets. From the moment a new product is ideated, through cost estimates, revenue projections and lead time calculations, everything that supply chain professionals do is based on a prediction of some future outcome. With their bets expressed as sales forecasts and budgets, organizations then move on to the arduous work of turning their prognostications into happy customers, full coffers and (hopefully) some form of social good.

Unfortunately, the future never works out as planned and that's when companies have to make adjustments between what they predicted would happen, and how things actually turned out. Reactionary by definition, tactical supply chain execution is a constant struggle to create a balance between what is required of a system and what it is physically (and now, digitally) capable of doing. Because global trade is just so darn difficult, executives need every resource and tool at their disposal to maximize the probability of success.

The good news is that Systems Thinking is about predicting the future, too, but in a way that is both different from, and complementary of supply chain management. Whereas much of supply chain is driven by achieving future objectives, Systems Thinking is meant to *anticipate* how systems variables will behave in an environment whose entire existence is designed to achieve those very same goals. Because it centers on how systems behave today, as well as in the future, Systems Thinking should be viewed as both a philosophy and practical methodology that helps to "bridge the gap" between what companies aspire to, and what reality holds in store.

> When you really think about it, supply chain management comes down to predicting the future and placing bets.

To be clear, this paper was never intended to present Systems Thinking as a panacea for a company's supply chain woes. The rise and decline of disciplines like TQM, Reengineering and Management by Objectives informs us that there is no one "true religion" that will save a supply chain, so ours will be a more realistic and secular path.

To that end, what this paper does purport to say is that the application of the Systems Thinking mindset to supply chain planning, execution, measurement and continuous improvement will increase a company's chances of success in today's hyper-competitive world. And when combined with the best of what other methodologies have to offer, a hybrid can emerge where, not unlike System Dynamics itself, the whole is much greater than the sum of the parts.

Like any School of Thought that's, "worth the candle", Systems Thinking is built upon a foundation of core tenets and Best Practices. The balance of this paper is dedicated to presenting those principles in a way that not only informs the reader, but that inspires people to explore the topic more deeply and perhaps, apply Systems Thinking to their own supply chain opportunities and challenges.

Adopt the Philosophy

The father of the Total Quality Management movement, W. Edwards Deming, published a book in 1982 entitled, *Out of the Crisis*. In Chapter 2, he provided a list of "14 Points for Management" that endure as the guiding principles of the TQM approach to continuous improvement. Recognizing that people do their best work when they truly believe in what they're doing, Dr. Deming's second point was, "Adopt the Philosophy".

While the principles of TQM do differ from those of Systems Thinking in some ways, the common ground they share is the knowledge that for organizations to be truly successful, people have to buy into the objectives, strategies, policies and methods that management espouses. When it comes

to a specific company, people's beliefs and values are based on the leadership team's philosophy, the totality of which is reflected in its culture.

In order for Systems Thinking to take root in a culture, team members have to believe in it. And while culture definitely drives behavior, the adoption of any philosophy is an individual journey, the result of which comes from study, dialogue, contemplation and in the end, a personal decision to either buy in, or not. Hopefully, this paper helps with the former of the two paths.

Expand Your Mental Model

Whether in business or our personal lives, every decision or action that we take is based on a mental model. Essentially a compilation of one's beliefs, experiences and perceptions, mental models determine how we think about the world in general, as well as how we act in specific situations.

Also known as a "Frame of Reference", our mental models drive the assumption-based decisions that we make, some of which may not be aligned with the realities of a supply chain system. As such, the goal must be to substitute abstract-based assumptions for knowledge, a process that requires a commitment to a lifetime of curiosity and learning.

The best way to replace an abstract with reality is to get out and see things first hand. Certainly a great idea, we all know that an entire company can't travel the world visiting every vendor and customer. That reality notwithstanding, companies can engage in cross-training, multi-functional meetings and projects that foster a broader frame of reference. Externally, they can hold regular web conferences with supply chain partners, as well as take video tours of factories, ports, airports, etc.

Know Your System Elements

When it comes to global trade, the best place to start broadening mental models is by making people 100% aware of every participant that constitutes a supply chain. As obvious as it sounds, there are many organizations that not only lack an understanding of what each player does, they're totally unaware that they even exist.

> "Much like an algebra problem can't be "solved for x" without awareness of every variable in the equation, feedback loops and countervailing forces can't be understood if we don't know who (or what) creates them."

Much like an algebra problem can't be "solved for x" without awareness of every variable in the equation, feedback loops and countervailing forces can't be understood if we don't know who (or what) creates them. Depending on the business model, supply chains can involve actors as varied as contract manufacturers, banks, cargo insurance firms, product testing labs, customs entities et al., so awareness of each of them, and what they do, is critical.

As Deming himself stated, "A system can't understand itself"[4], so it is up to the people that run a global operation to be intimately familiar with every aspect of it. As a first step towards Systems Thinking, cross functional teams should create a visual portrayal of all supply chain actors, with a brief description of the product, service or function they provide. Albeit a simple beginning, awareness and understanding of "who's who in the zoo" sets the stage for other Best Practices.

Identify Sub-Systems

Within the framework of identifying participants in a supply chain, it is also important to note that many players are part of a sub-system made up of entities engaged in similar, or complementary activities. Equally applicable to the internal mechanics of a company, the ability to identify sub-systems and how they interact with one another, is yet another important part of treating supply chains as an Information Feedback System.

The two biggest sub-systems inherent to any global operation are what we'll call, the "Buy Side" and "Sell Side" of a supply chain.

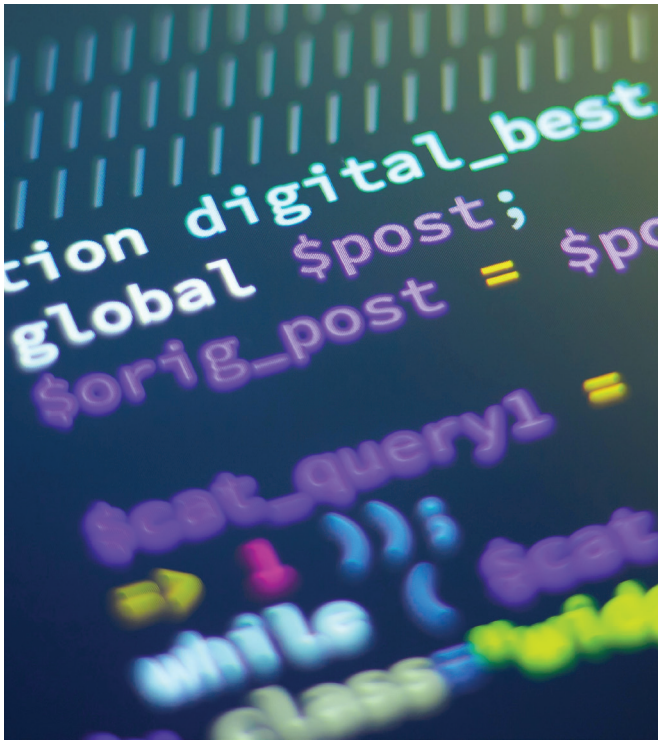
Of course, the former concerns itself with the procurement/manufacture of goods and services that are in turn marketed, distributed and sold by the latter. For example, a Buy Side sub-system is an importer's sourcing and purchasing departments that work with overseas suppliers, where a Sell-Side sub-system could be the internal logistics department that works with Third Party Logistics firms to fulfill customer orders.

There is a very important caveat attached to identifying sub-systems: Always remember that the feedback loops, countervailing forces and unintended consequences that sub-systems generate are not limited to the sub-system itself. Quite the contrary, and as we've stated throughout this paper, feedback loops permeate all facets of an operation and as such, we must be aware that the decisions and actions we take are indeed far reaching in both time and space.

Draw Up and Study Feedback Loops

Because feedback loops are the essence of Systems Thinking, supply chain teams must engage in a permanent cycle of identifying, mapping and channeling their energy in a direction that benefits the entire system. Be they of the Reinforcing or Balancing variety, it is the dynamics that go on between system elements that bring forward countervailing forces, as well as unintended consequences.

At this time, it must be explicitly noted that the mapping and management of feedback loops is applicable to both existing, as well as



future operations. For existing operations, the ongoing practice of Current State Analysis should incorporate a Systems Thinking approach that exposes the virtuous, as well as vicious cycles that work their way into every system.

As executives formulate new strategies, policies and tactics, multi-functional teams should engage with external supply chain partners to at least try and predict the emergence of future feedback loops. By no means a guarantee of success, it is irrefutable that at the very least, futuristic attempts at anticipating Reinforcing and Balancing Feedback Loops will help drive down the probability of missteps, wasted resources and outright failure.

> Without question, adoption of the Systems Thinking philosophy is the cornerstone to becoming a Learning Organization and when empowered by Artificial Intelligence, there's no limit to what man and machine can achieve together.

Sales & Operations Planning is Ideal for Systems Thinking

The supply chain discipline known as "Sales & Operations Planning" (S&OP) is an ongoing activity whereby multi-departmental teams compare sales forecasts with actual demand, and upon identifying the inevitable variances between the two, make adjustments to the Buy and/or Sell Side of their supply chain.

Without question, Systems Thinking should never reside in a single department or in the minds of a few select individuals. However,

S&OP is an ideal place to implement Systems Thinking because a) its intent is to evaluate the recent past in a way that positively impacts the future and b) S&OP requires that people make decisions to "bridge the gap" between what they predicted in a forecast or budget, and what's really going on in a supply chain.

Whether a company is contemplating an increase in production for a hot product, or cancelling purchase orders on overseas suppliers for items that aren't selling, the decisions they make will generate movement within existing feedback loops, and likely create new ones. When the S&OP function incorporates Systems Thinking into its overall processes, the prospects for making well-informed and forward thinking decisions improve dramatically.

Harness the Power of Artificial Intelligence & Machine Learning

From its inception, the founders of Systems Thinking knew that there is a limit to how much data the human mind can process, and that it is especially difficult for people to identify all of the interactions that go on between the elements of a system. Recognition of this fact inspired Vannevar Bush to invent the Differential Analyzer and it's why early computers were designed to do long math.

Much has changed since the 1930's and software is not only able to mine and organize Big Data, it has evolved into a new field known as "Predictive Analytics". In the field of supply chain management, the entire eco-system has benefited from advances in data-driven forecasting, as well as the ability to identify soon-to-emerge problems, and even predict future outcomes.

Given the ever-advancing state of supply chain software, a Systems Thinking corporate culture should be supported by technologies that enhance the ability to detect virtuous feedback loops that drive success, while simultaneously uncovering vicious cycles, countervailing forces and unintended consequences *before* they can do any damage.

Empowering Global Trade: Systems Thinking and Artificial Intelligence

Since the invention of the Differential Analyzer in 1931, Systems Thinkers have relied on technology to tackle the most complex of issues. By combining historical data with algorithms that simulate the behavior of feedback loops, data scientists have become increasingly more accurate in their prediction of future outcomes.

While there are many ways in which technology can be applied to supply chain operations, three areas have emerged that seem to have the greatest potential to augment the Systems Thinking approach. Below is a brief description of each:

Descriptive Analytics: More of an "in the moment" tool, Descriptive Analytics uses access to real-time data to identify and describe both positive and negative outcomes. For example, if sales of an outdoor heater used by restaurants are spiking, a system capable of Descriptive Analytics will proactively notify multiple parties of every detail associated with the occurrence. Conversely, if an export shipment is outside of its lead time tolerance due to a customs delay at destination, the system will flag that type of occurrence, too.

Given the importance of uncovering both existing, as well as future feedback loops in a supply chain, the ability of Descriptive Analytics to not only describe events, but pinpoint existing feedback loops represents a substantial advance for Systems Thinking.

Prescriptive Analytics: In the case of Prescriptive Analytics, software doesn't just describe an occurrence; it provides suggestions on what to do about the issue or opportunity. In the example of the outdoor heaters, the software incorporates multiple variables into its simulations (e.g. time of year) and suggest either procuring more units, or letting them sell out, albeit at a higher price.

In making determinations about how to react to a given situation, the future of Systems Thinking lies in the ability to prescribe alternative paths, as well as provide simulations of the feedback loops that are created as a result of a chosen decision or action. Given this need, advances in software-based Prescriptive Analytics would be a boon to Systems Thinking.

Predictive Analytics: For purposes of identifying the feedback loops and system behaviors that are born of future strategies, decisions and policies, Predictive Analytics has the greatest potential for use in supply chain management. Ideally, not only should Predictive Analytics forecast outcomes, software must also be capable of simulating the future interactions between system elements that will invariably create new feedback loops.

As an example of the above, the leadership team at Valentina's Fashion House would have benefited considerably from a software tool that not only predicted issues with system variables like production capacity and unstable lead times, but that simulated the feedback loops that led to the existential problem no one anticipated: Nearly running out of cash.

Look for Countervailing Forces & Unintended Consequences

Being able to identify both existing, as well as future feedback loops is important, but it's really only the beginning of an ever-evolving process. To have any real impact on a supply chain, folks have to also expose the countervailing forces and unintended consequences born of those loops. It's for this reason that feedback loop mapping exercises must incorporate efforts to uncover such phenomena.

When seeking out countervailing forces and unintended consequences, be reminded that we're not just looking for "who" pushes back on a decision or action. Of equal importance is the ability to expose "what" within a system can impede progress. As we saw in the case of Valentina's Fashion House, the limited production capacity of their Indonesian vendors and delays in the trans-shipping of ocean containers were two systems characteristics that set them up for failure.

To help uncover systems characteristics that work as countervailing forces, we might consider an iteration of a Lean Six Sigma tool called "Five Why Analysis". Just like 5WA requires teams to question a strategy, policy, decision or tactic at least five times, when seeking out or predicting unintended consequences, we might use a "Five How Approach" that compels teams to proactively envision scenarios on the ways in which future feedback loops might behave.

Question Every Assumption

Mental models are the basis for assumptions, and the truth is that no one person possesses a frame of reference broad enough to allow any assumption to go unchallenged. As such, and if for this reason alone, organizations must work in multi-functional teams, as well as engage supply chain partners in an ongoing practice of questioning the assumptions behind every strategy, decision or action that they take.

In the mid-nineties, Walmart popularized a methodology known as, "Collaborative Planning, Forecasting & Replenishment" (CPFR). With an emphasis on involving people from all departments within their internal operation, as well as engaging customers and vendors, CPFR compelled all participants to identify and question every assumption tied to a given decision-making process. In spite of the absence of a fancy name and acronym, the same procedure must be part of Supply Chain Systems Thinking.

Become a Learning Organization

If Systems Thinking really is about coming full circle, then the goal for international companies must be to morph into what Peter Senge called a "Learning Organization". In the end, any firm's success in global trade comes down to the ability to compete, and without an environment that encourages learning-based invention, innovation, risk-taking and mistake making, any semblance of market advantage will be short-lived.

The process of becoming (and remaining) a Learning Organization represents the ultimate in virtuous cycles and must be founded upon a managerial philosophy that fosters human development across the entire supply chain system. From customer visits to training sessions or impromptu exchanges at the water cooler, people must be encouraged to develop both individually and more importantly, as a system.

Global trade isn't easy and while there are no guarantees in supply chain management, the more people work to gain functional expertise, expand their mental models, develop empathy and apply what they've learned to actual opportunities and problems, the better off the organization will be. Without question, adoption of the Systems Thinking philosophy is the cornerstone to becoming a Learning Organization and when empowered by Artificial Intelligence, there's no limit to what man and machine can achieve together.

Summary

From the outset, the goal of this paper has been to demonstrate how Systems Thinking can enhance supply chain planning, execution and continuous improvement. That process began by highlighting the people, technologies and events that legitimized Systems Thinking as a true engineering discipline. Without question, the crowning moment for Systems Thinking came in 1971 when the simulation software "DYNAMO" predicted a climate crisis by the year 2020.

Based on those historical foundations, the paper went on to point out the parallels that exist between the principles of Systems Thinking and the behavioral characteristics of an international business operation. With an emphasis on abandoning linear thinking for a more circular orientation, supply chains were portrayed as Information Feedback Systems whose outputs are driven by the perpetual interactions that go on between all actors in the system.

As the paper pivoted to the specifics of how Systems Thinking can be applied to global supply chain management, traditional examples like The Beer Game and the Bullwhip Effect helped to introduce all-important concepts like feedback loops, countervailing forces and both virtuous, as well as vicious cycles. Hopefully, the VFH case study accentuated the role that mental models and assumptions play in strategic planning and results, and that the unintended consequences born of our actions show up at the most inopportune times and places.

> "Hopefully, the thoughts and observations found herein have compelled the reader to buy into the idea that, "*When it comes to global supply chain management, what goes around, really does come around*".

At some point, Systems Thinking has to go from being a philosophy to creating practical value. Accordingly, a list of techniques and best practices were presented with the intent of helping supply chain professionals to take a "building block" approach to applying Systems Thinking to real-world situations. Of particular significance was the role that Predictive Analytics software will continue to play in supporting the work of multi-national organizations.

Ultimately, supply chain management is about predicting future outcomes and then making adjustments when actual results differ from what was forecasted. As such, executives need every tool at their disposal to not only reduce supply chain variances as they surface, but to expose the source(s) of those variances well in advance. Given its futuristic approach to identifying the feedback loops that drive systems behavior, Systems Thinking can do just that.

Hopefully, the thoughts and observations found herein have compelled the reader to buy into the idea that, "When it comes to global supply chain management, what goes around, really does come around". In that sense, may this paper serve as a starting point for further investigation into ways in which Systems Thinking can help companies to enhance their own chances of success, while contributing to the well-being of Mother Earth.

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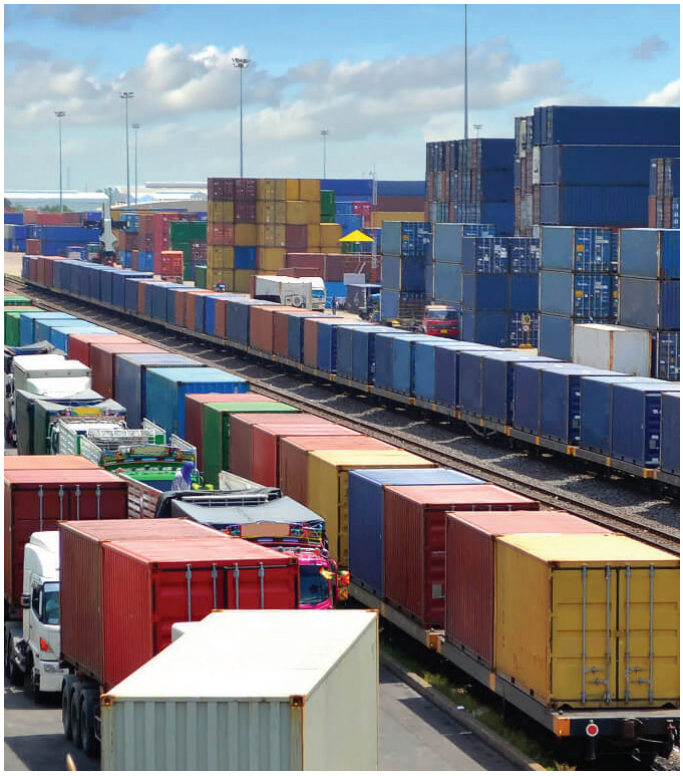

Footnotes

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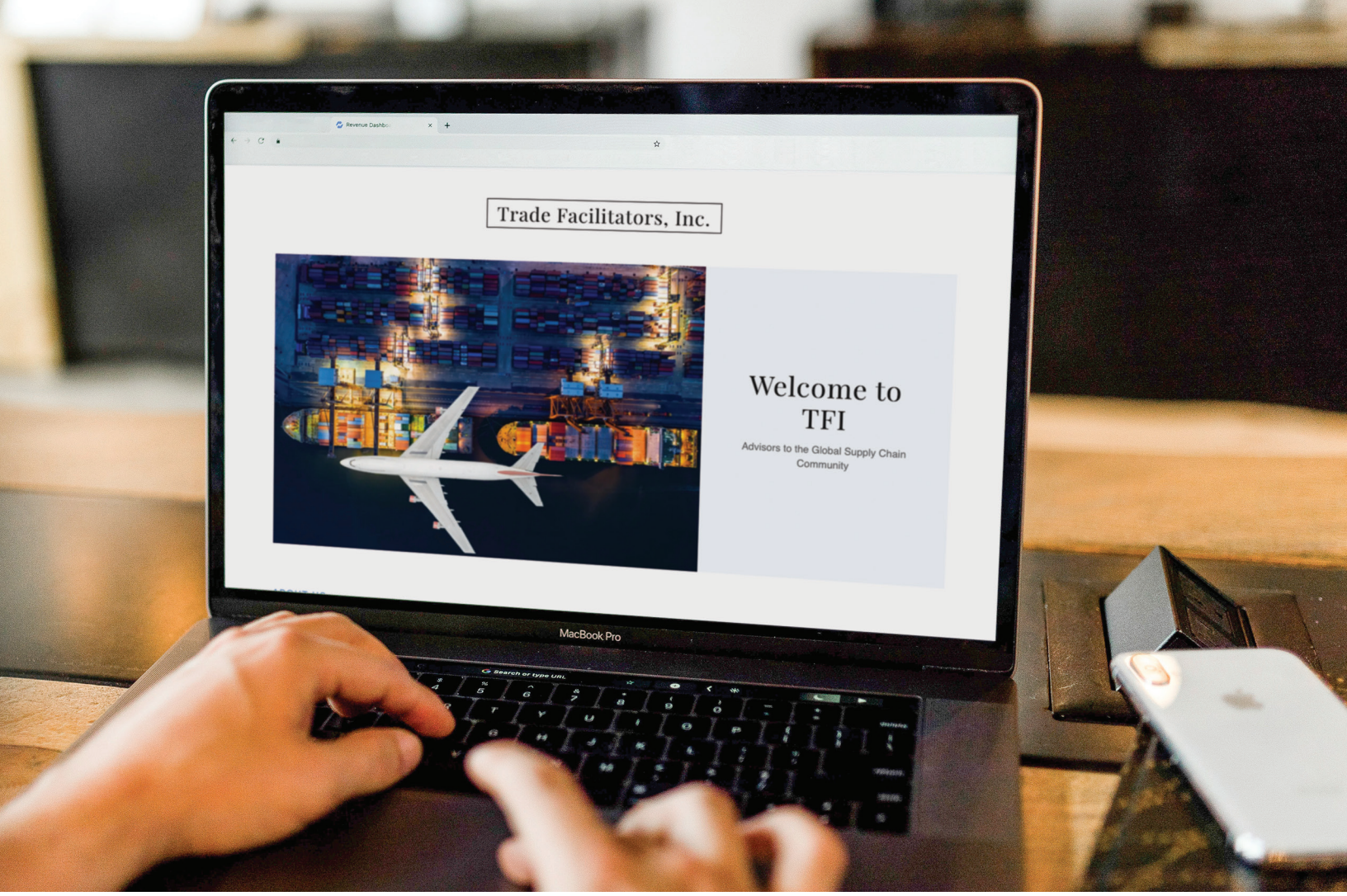

About the Author

Dan Gardner is president of Trade Facilitators, Inc. (TFI), a Los Angeles based consulting firm dedicated to the fields of global supply chain management, logistics and trade compliance. Prior to founding TFI, Dan worked in the 3rd Party Logistics industry where he held senior roles that include President of Latin America for Exel Global Logistics, President of Ocean World Lines and SVP USA with DHL Global Forwarding.

Mr. Gardner's activities at TFI focus on consulting with Beneficial Cargo Owners, as well as providing strategic, operational and commercial advice to technology startups in the logistics and supply chain space. Dan also serves as Chairman of the Advisory Board for STG Logistics, the largest bonded Container Freight Station operator in the U.S.

In addition to his professional experience, Dan has been an adjunct professor of supply chain management his entire career. In 2002, Mr. Gardner was selected as the Professor of the Year in the Masters of International Business Program at Florida International University and in 2014 he earned the "Top Instructor" distinction at the California State University Long Beach Center for International Trade & Transportation. Dan remains on the faculties of CSULB, Georgia Tech and Long Beach City College.

A native of Lynn, Massachusetts, Mr. Gardner holds an MBA from the University of Miami and is a licensed Customs Broker in the U.S. Dan has also been certified in Production & Inventory Management (CPIM) by The American Production & Inventory Control Society (APICS), holds a Black Belt in Six Sigma and earned a certification by the American Society for Industrial Security (ASIS) as a Physical Security Professional.

During his career, Dan has travelled to fifty countries, having lived in Colombia and Mexico for a total of five years.

Mr. Gardner can be reached at dgardner@tradefacil.com.