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The LIVING Supply Chain

New Rules for the New Normal

It was raining hard in San Jose the morning I walked from the A-Loft Hotel to meet Tom Linton at the Flex offices.

“We don’t usually get this much rain,” several locals had informed me, “but we are sure glad, because we need it. Four or five years of droughts have really depleted our water supply.”

I had driven by the site of the 2016 Super Bowl the night before – a site where the favored Carolina Panthers offense would be decimated by an attacking Denver Broncos defense, a reminder that a great defense can beat a good offense.

Our meeting began with a broad overview of Flex. The name change from Flextronics to Flex had occurred in July 2015, in response to the fact that the company was no longer a “contract manufacturer” in the traditional sense of the word.¹ Contract manufacturing was Flextronics’ original business, during the boom years of the 1990s and the Internet boom, when the company largely manufactured PCs for big names like HP, Dell, and others. Contract manufacturing was a volume business, with razor-thin margins, and it relied on a company’s ability to scale up a new product assembly line anywhere in the world. I had written about Flextronics in one of the first-ever supply chain books, *Introduction to Supply Chain Management*, published in 1999.

“We are no longer a contract manufacturer,” Tom emphasized, “but we are in full transition to become a company that, when I think about it, hasn’t ever existed before. In each of the organizations I’ve worked in, I like to experiment with organizational models. This is the biggest experiment of them all, and I believe we are achieving an essential alignment of procurement and the supply chain organization that is unique. We are influencing and shaping Flex’s corporate strategy, but we are also totally supporting it.

¹ The terms Flextronics, Flex, Sketch-to-Scale™, Intelligence of Things™, the Pulse Center™, and other terms in this book belong to Flex International Ltd., or its affiliates.

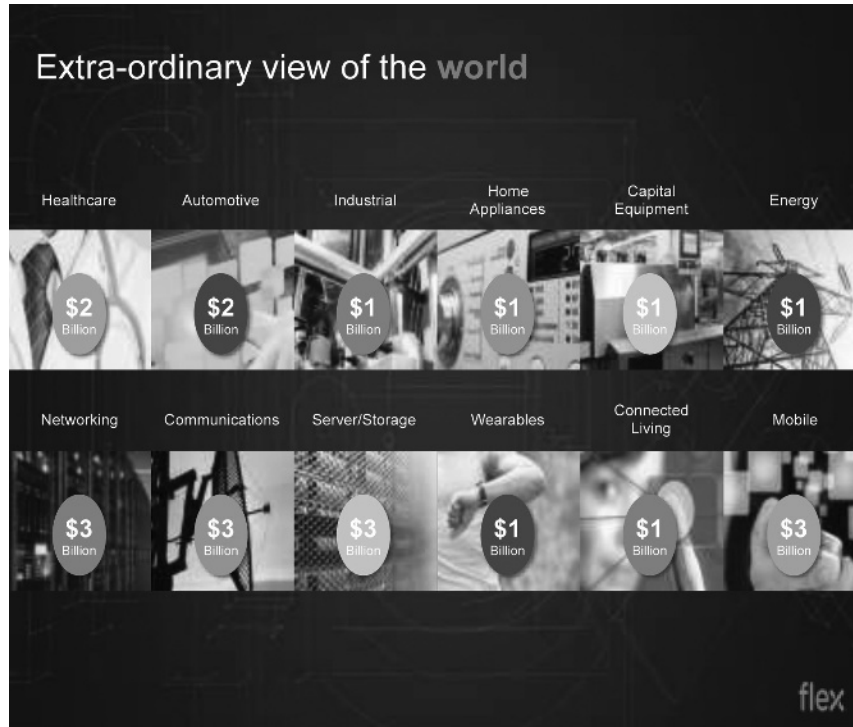


Figure 1.1 Flex’s Business Divisions. Source: Reproduced with permission of Flex

“We are a capability supply chain company,” Tom said. “Supply chain is our business, but it is supply chain on steroids. We have over 200,000 employees and over 1000 customers in 18 different industries, and produce \$1 billion or more in at least 12 of these verticals”, referring me to a chart showing all of Flex’s business verticals (Figure 1.1). “I’m involved in the downstream supply and manufacturing side, as well as the upstream, quoting to our customers when they come to us for a new product. We call it ‘Sketch-to-Scale™’ to represent what we do from design through manufacturing. We incubate startups and drive scale for large original equipment manufacturers. We don’t just make PCs anymore – but produce just about every electronic product you can think of that’s out there. We make cell phones, Nike footwear, industrial products, Wink networks for the connected home, Bose speakers, Apple servers, Microsoft X-boxes, Fit-Bits, drones, and dozens of devices for the emerging connected world. We produce medical products for J&J, Cisco products, and automotive products for Ford. We’re a significant player in everything from floor care (Dyson, Bissell) to industrial test equipment and solar energy and

are running billion dollar businesses in each of these sectors. But you won't ever see our name or our brand on these products. We are one of the biggest companies nobody has ever heard of, and we are continuing to expand in other areas." In late 2016, Flex announced that they are partnering with a company Rib Software to form a joint venture, YTwo Formative, to digitize the acquisition of building materials in a revolutionary set of solutions for the \$9 trillion housing industry.²

Droughts and Super Bowl outcomes are just two of the many uncertainties facing the population in our global ecosystem. One-in-a-thousand-years rain like the one that hit South Carolina in October 2015, the Tianjin explosion, the Bangkok monsoon flooding, and the Japanese earthquake/tsunami and resulting devastation are just a few of the natural disasters to hit global supply chains in the last few years. These disasters create disruptions, but nothing like the disruptions brought about by global terrorist events, political foment and civil unrest, worker strikes, increased challenges in border crossing, and labor issues that are part and parcel of the global supply chain. As any student of business history knows, globalization has brought about a huge number of discontinuities and disruptions. These disruptions are no longer unique and rare; they are ubiquitous, and the time between disruptions seems to be shrinking. In fact, it is a rare day when no disruptions of any kind occur.

Managing volatility would be an acceptable strategy if the return on this level of risk were high. But that doesn't seem to be the case. The press continues to talk about stock market volatility, with pundits predicting that the economic downturn in China will impact the global market. Low oil prices, low commodity prices, and low food prices had everyone worried, as this indicated that demand was also low. Growth rates were predicted to be anemic. A collection of CEOs in Davos, Switzerland, predicted doom and gloom,³ as validated by a Deloitte survey of 1700 executives who all felt that there would be negative growth in the year ahead. Britain's 2016 vote to enact Article 50 and exit the European Union ("Brexit") has caused panic and uncertainty for Europe and the UK, with UK officials running around frantically and interest rates reaching new lows. Indeed, there seems to be no upside. Worse, experts noted that volatility "is the new normal," and that there isn't much hope for stability.

In January 2016, economists predicted that United States and global GDP growth would hover between 1.9% and 2.4% based on slowing growth in China. The outlook in January 2017 also hovers around 2% in the face of a Trump presidency, while global GDP is predicted to be at 2.9–3.4%.⁴ Lower investment, unfavorable demographics, and weak productivity growth are the hallmarks

2 <http://www.prnewswire.com/news-releases/flex-and-rib-software-join-forces-to-transform-building-and-housing-industry-300367092.html>

3 <http://www.pwc.com/gx/en/ceo-agenda/pwc-at-davos.html>

4 Doerfler, S., "The Big Unknown," *Inside Supply Management*, January 2017, pp. 17–21.

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Table 1.1 Real GDP Growth (%)

Country Groups	2013	2014	2015	2016	2017	2018
Aggregates						
Advanced economies	1.1	1.7	1.8	1.7	1.9	1.9
High-income economies	1.2	1.7	1.6	1.5	1.9	1.9
Developing economies	5.3	4.9	4.3	4.3	4.9	5.1
Low-income economies	6.5	6.1	4.5	5.3	6.3	6.6
BRICS	5.7	5.1	3.8	4.2	5.1	5.3
Emerging market and developing economies (EMDEs)	4.7	4.2	3.4	3.5	4.4	4.7
World	2.4	2.6	2.4	2.4	2.8	3
Regions/Economies						
Europe and Central Asia	2.3	1.8	-0.1	1.2	2.5	2.8
Latin America and the Caribbean	2.9	1	-0.7	-1.3	1.2	2.1
Middle East and North Africa	2	2.9	2.6	2.9	3.5	3.6
Sub-Saharan Africa	4.8	4.5	3	2.5	3.9	4.4
East Asia and Pacific	7.1	6.8	6.5	6.3	6.2	6.1
South Asia	6.1	6.8	7	7.1	7.2	7.3

Source: Reproduced with permission of World Bank

of the global economy⁵ – certainly nothing that anyone is looking forward to. Business confidence is lower, manufacturing is “quiet,” and rapid changes in this environment are causing many supply chain executives to scratch their heads and wonder how to deal with an economy that is at best subdued. Hopes that the Trans-Pacific Partnership might boost production due to removal of the more than 18,000 taxes on American exports were dashed when President Trump withdrew from the agreement. There are increasing signs that the once-popular trend toward open borders and globalization is moving toward regionalization and protectionism (Table 1.1).⁶

Increased complexity in the global economy is adding another layer of malaise to supply chain executives. As customers are increasingly demanding “customized” solutions, companies are forced to produce in smaller quantities, leading to what is known as “mass customization.” Increased regionalization of

5 Siegfried, M., “2016: A Year of Transitions,” *Inside Supply Management*, January 2016, pp. 22–24, <http://www.worldbank.org/en/publication/global-economic-prospects>

6 <https://scm.ncsu.edu/blog/2016/07/08/the-growing-fragmentation-of-global-trade-guest-post-by-tim-barnes/>

product regulations and even localization requirements are driving increased scrutiny of shipments across borders, as well as new packaging and traceability requirements. The move toward e-commerce and shipments to end consumers via Amazon and Ali Baba is driving smaller packages, increasing congestion on city streets due to more deliveries, and escalating the potential for logistical malfunctions. How will companies survive?

One approach that many companies have sought in order to reduce risk in this environment is to *outsource* to third parties like Flex. Outsourcing involves divesting your company of processes that once were done internally, and have, them done by third-party suppliers. Because Flex works as a contract manufacturer across 18 of the largest global industries, it essentially acts as an absorber of global risk for many customers, including Apple, Ford, Amazon, and others. On the other hand, this structure also provides companies like Flex with the power of global insight. Each of the 12 verticals to which Flex contributes represents more than \$1 billion in business. But, this value only represents the cost of goods sold for the end customer; since brands in electronics and other industries often mark up their products, the real revenue impact is often two, three, or four times higher. In each one of these business segments, Flex typically has 30–50 customers and often builds the newer technology products that, while cutting edge, require low-cost manufacturing in order to maintain market-friendly pricing.

As a result, Flex can triangulate across operations strategies, geographic strategies, and product strategies like no other company. It also can begin to predict how technologies, consumer behavior, supply chain innovations, or digitalization that are emerging in one sector – say the consumer products segment – may appear in automotive or medical products tomorrow. For example, who ever thought people could one day play music in their cars from their portable phones?

Learning More About Flex: A New Business Model

In his role as Flex's chief supply chain officer, Tom Linton runs an end-to-end supply chain. But end-to-end *really* means end-to-end – including customer-facing flows, supplier and material-facing flows, and all the sourcing and logistics in between. One organization manages all of it – because all these processes have to be so tightly linked. This is tricky, because non-disclosure agreements between customers may prevent Flex from spanning boundaries in the business with other customers who are their competitors!

Flex's supply chain organization controls sourcing on electrical, direct, and indirect procurement, and also oversees all materials at over 120 global site locations, including all the intellectual property, inventory, cash cycle, days sales outstanding, days payable outstanding, and the entire financial workflow

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of the organization. When their Chief Supply Chain Officer (Linton) presents to leadership, he is effectively talking to them about managing the balance sheet and the income statement, as well as supporting incoming revenue.

The biggest advantage of this level of oversight is that it allows Linton to align organizational capability and financial outcomes with procurement and supply chain strategy. In so many supply chains, the different pieces of the supply chain are often misaligned. Information systems have, for years, tried to “integrate” these disparate pieces, but this has still resulted in misalignment of decisions, primarily for political reasons. Every function has its own agenda, its own performance measures, and its own culture, and operates in a silo. Installing an ERP system to “Integrate” these parts does little to address these disparities.

Linton puts it this way: “All of the pieces, for the first time in my career, are fully aligned. I’m fortunate that Flex is an organization that readily welcomes change and adaption to a change ecosystem, and is able to attract and retain very talented people because of that. It is like a big chiropractic alignment, and when it happens, it is truly the secret sauce of successful organizations, versus those that remain functionally aligned with functional strategies that aren’t aligned. We have true visibility to all financial flows, which ensures that we are profitable.”

The Milpitas site that we visited later that morning was the location for much of the R&D in the company. We were traveling to Building 2, where many of the prototyping and new technology start-ups were experimenting with prototype and design-scaling efforts. Once these new processes are developed, Flex scales them up in different parts of the world – Brazil, China, Mexico, or wherever they are appropriate for a Flex customer.

Companies like Cisco, Microsoft, and Apple all have a huge market cap, but their manufacturing activities are unlimited. Flex manages all these activities for them, which means Flex must run a top-notch end-to-end supply chain. So even though you won’t see a “Made by Flex” label on these companies’ products, Flex is in the background, ensuring that everything is coming together. This is one reason that Flex and other contract manufacturers are emerging as the fabric of the emerging trend toward what Flex calls the “Intelligence of Things™.”

The other interesting anomaly is that “top 25” lists of the “best supply chains” at Gartner⁷ often list these very companies: Fitbit, Amazon, Apple, Cisco, Nike, Inditex, Samsung, Intel, H&M, Lenovo, and others. Tom noted, “We manufacture for many of these companies, and actually hold a lot of their assets for them. So when Gartner measures the top supply chains, one of the criteria they use is the ratio of the company’s revenues to its assets. All these companies are asset-light – because Flex is holding their inventory for them!”

⁷ <http://www.gartner.com/technology/supply-chain/top25.jsp>

Now my interest was really piqued. Flex and others like them hold a lot of the inventory and material and manage the shipping flows for these big companies. How does that work? How can one company manage so many supply chain processes and so many customers?

A Brief History of Supply Chain Management (The New Rules of LIVING Supply Chains)

The new Flex supply chain structure in this book is part of a massive evolution in today's supply chain world. These changes will occur sometimes quickly, sometimes slowly, but will undoubtedly come into being in the next decade. The changes we write about in this book are not just about technology – they are about true evolution, in a biological sense. In fact, many of the changes we are seeing have been captured in a set of statements we call the “Rules of LIVING Supply Chains.” These new rules are aligned with many of the rules that dictate how species, human beings, and genetics have evolved, and represent a natural, rather than a radical evolution. They are occurring because the world of global trade is reshaping the way we operate. In a sense, this world has reached the limits of growth. The new rules will require a new set of management approaches, as the traditional approaches to managing the supply chain will no longer apply.

To understand this, a brief history lesson is in order. Supply chain management as a field continued to evolve as large organizations saw the need for dedicated functions responsible for management of materials, which included purchasing raw materials, managing manufacturing processes, and moving materials (logistics). The mid-1960s witnessed a dramatic growth of, and interest in, the materials management concept. Still, the concept's origins date to the 1800s. Organizing under the materials management concept was common during the latter half of the 19th century in the US railroads, which combined related functions such as purchasing, inventory control, receiving, and stores under the authority of one individual.

External events directly affected the operation of the typical firm. The Vietnam War, for example, resulted in rising price and material availability pressures. During the 1970s, firms experienced material problems related to oil “shortages” and embargoes. The logical response of industry was to become more efficient, particularly in the purchase and control of materials. Widespread agreement existed about the primary objective of the materials concept and the functions that might fall under the materials umbrella. The overall objective of materials management was to solve materials problems from a total system cost perspective rather than from the viewpoint of individual functions or activities. Functions that fell under the materials umbrella included material planning and control, inventory planning and control, materials and procurement research, purchasing, incoming traffic, receiving,

incoming quality control, stores, materials movement, and scrap and surplus disposal.

Rob Handfield witnessed the evolution of the management field now known as “supply chain management” as a young assistant professor at Michigan State University (MSU). Handfield was part of a group called the Global Procurement Benchmarking Initiative, led by Dr. Robert Monczka. During his time at Michigan State (1992–1999), the GPBI benchmarked more than 300 global companies, and set forth many of what became known as the principles of “World Class Procurement.” Many of these principles became the foundation for consulting practices at Accenture, Deloitte, Booz Allen, and others. At the time, these principles were appropriate. The idea was that procurement needed to establish a position not just as a “buyer of stuff,” but as a centralized function that tabulated spending across both direct and indirect categories of spending, leveraged this volume through purchase power, and sought to achieve significant cost improvement. Business consultants also began looking at procurement as a vehicle for measuring supplier performance, improving suppliers through development activities that needed help, and acknowledging that some relationships with suppliers needed to be more strategic than others. As purchasing became more efficient, the term “strategic sourcing” was coined, which involved combining volumes of requirements from across the business, grouping them into large bids that went out to suppliers, and driving down costs due to larger quantity discounts achieved. This also led to the use of “reverse auctions,” in which suppliers would bid on these quantities online. In logistics, the focus became on centralizing distribution centers and warehouses to drive optimization in transportation routing and reduce inventory across the system.

Many of the traditional concepts that evolved from this perspective of “driving cost of materials lower” focused on increasing the efficiency of operations in the supply chain from supplier to end customer. Many of these principles also coincided with the introduction of “lean manufacturing,” based on the “just-in-time” thinking pioneered by the likes of Toyota. For example, the “Theory of Constraints”⁸ emphasized that to optimize an end-to-end system, “bottlenecks” had to be addressed by adding capacity at this operation. “Just-in-time” and “lean manufacturing” focused on standardizing products, improving coordination between different enterprises to reduce inventory, and only delivering the exact amount needed, in quantities that could be immediately consumed by the follow-on operation.

Another group at MSU, led by Dr. Donald Bowersox, also spurred new thinking on the “Logistics Renaissance,” proclaiming that the role of logistics was to add value and drive market penetration through technology integration. All the

8 Goldratt, E., *The Goal*, 2nd ed., North River Press, Great Barrington, MA, 1992.

work done in this period highlighted many important issues, encapsulated in a “maturity model” that identified how organizations could develop these capabilities over time toward a truly “world class supply chain” organization.

However, “world class” still emphasized distinctions in the field. Purchasing, operations, and logistics were still viewed as disparate functions, and arguments broke out over which area should dominate. The three groups involved in these activities (purchasing, operations, and logistics) were lumped together as “supply chain” functions, but never stopped working independently of one another. Professional disputes emerged among the logistics, operations, and purchasing trade associations over who was really in control of the supply chain; purchasing felt they were calling the shots, while logistics professionals claimed that they had oversight over all movement of material in the chain. All the while, they claimed to be driving “world class procurement” or “world class logistics” practices, implying that these practices are the best of the best. “Technology integration” was intended to bring these groups together; however, lingering tensions, discontinuities, and waste in the end-to-end supply chain of many organizations still exist. Sure, they could buy things more efficiently and ship things more efficiently – but were they really linked? Hardly.

In the end, there are some real problems with the “world class” view of the supply chain. Although transactional excellence and efficiency is certainly an operative element that forms the basis for excellence, there is a shift away from the idea that “world class” applies to every situation. A supply chain executive at BP stated this very well: “World class is simply a set of tools on a tool belt – but the real wave of change involves understanding the business well enough to apply the tools that will drive a total cost view of end-to-end value stream. Supply chain analysts are too focused on getting an answer that is cost-optimized, rather than focusing on an outcome. And a centralized world-class solution is not always appropriate in every operation globally, because a single model may not work for every small, medium, and large operation. And so we need to approach the problem with a different tool belt, and be ready to use a number of different tools depending on the different business drivers and geographic components that are in play in different situations.”

So, if “world-class supply chain management” is no longer the objective, what is the next generation of supply chains going to look like? To answer this, it is important to emphasize that managing supply chains is no longer just about cost optimization, but about deep understanding of the components of customer value, and making decisions quickly in response to sudden shifts in customers’ requirements. While cost optimization may well be one element of this equation, value has many meanings. Managing the supply chain first and foremost requires that managers act as internal consultants who spend most of their days listening closely, not just to the explicit needs of internal customers for materials, information, services, knowledge, and capability, but also to the intangible elements customers need. In a sense, real-time supply chains involve

understanding and predicting what internal users and customers will need right now, even before they themselves recognize that they need it. And velocity/speed is an integral capability that requires quick response to customer needs to create the right capability.

The New Rules of the LIVING Supply Chain

Attention to speed and velocity is also an idea promulgated by evolutionary economics and biologists, who emphasize that organisms and creatures that are quick to respond will evolve more quickly, and will survive. Those who don't will die out. One of the best books to cover this concept is "The Serengeti Rules" by biologist Sean Carroll. Carroll explains how and why entire ecosystems can get "sick" when the populations of certain members are too low or too high. In fact, these rules provide an excellent set of guidelines for thinking about how supply chains operate as an ecosystem; instead of applying the rules to animals or biological entities, we have applied them to enterprises. In this manner, we propose the idea of a "LIVING" supply chain as one of a set of networked enterprises that are subject to biological rules.

Biologists have observed that systems of animals, birds, insects, and bacteria depend on one another for survival, and in fact can be characterized as "food webs" (Carroll, p. 39). An example of one of such food web links nitrogen, bacteria, plants, spiders, gulls, dung, puffins, arctic foxes, polar bears, seals, and other animals based on observations by Charles Elton in the 1920s. Elton visited the Arctic Islands and created a "food-cycle" schematic that showed the interconnected set of chains and webs that existed between species on the Bear Island (see Figure 1.2).⁹ In this figure, one can trace the chain that begins with nitrogen and bacteria at the upper left, and traces the link all the way through land birds, which provide food for the arctic fox. Other scientists (Smith, Hairston, and Slobodkin, going by the acronym of HSS) suggested that there are four general "trophic levels" of biological communities¹⁰: decomposers (fungi and worms), producers (plants and algae), herbivores (birds, insects, etc.), and carnivores (sharks lions, etc.). In this framework, the well-known HSS hypothesis emerged that "predators regulate herbivore populations," and that the removal of predators can lead to an explosion in herbivore populations. The reverse has also been shown to be true: Sea otters "induce" the growth of kelp by repressing the population of sea urchins. Other examples of "trophic cascades" include bass–minnows–algae, wolves–moose–fir trees, and armadillos–leaf-cutter ants–trees.

⁹ Carroll, S., *The Serengeti Rules*, Princeton University Press, 2016, p. 39.

¹⁰ Hairston, N., Smith, F., and Slobodkin, L., "Community Structure, Population Control, and Competition," *The American Naturalist*, vol. 94, no. 879, November/December 1960, pp. 421–425.

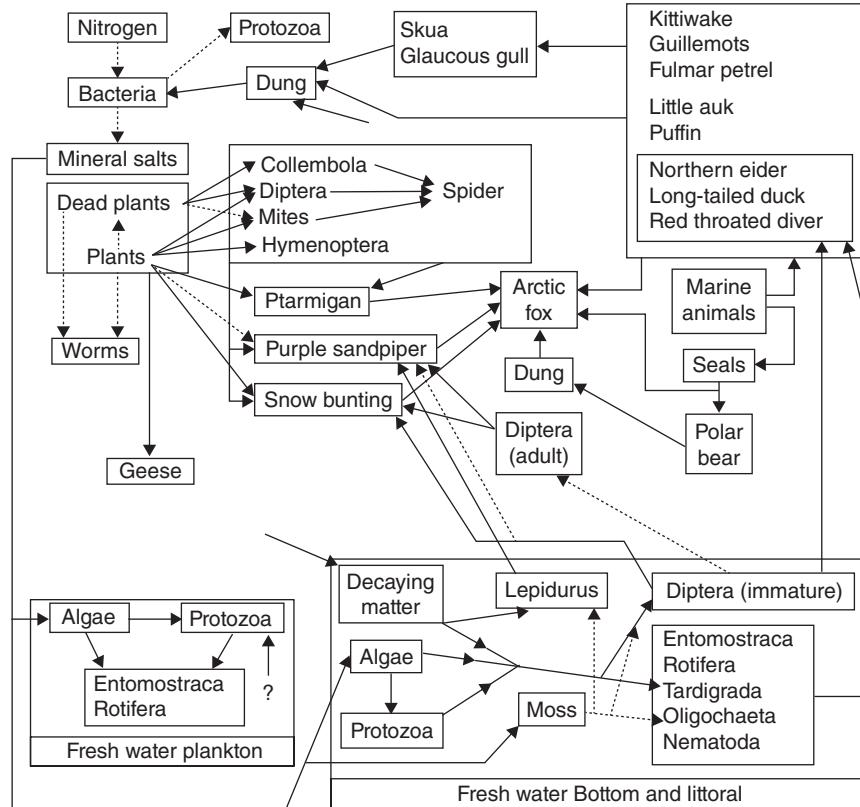


Figure 1.2 Charles Elton Figure of the Arctic Island Food System. Source: Reproduced with permission of Princeton University Press

These observations comprise the elements of the *Serengeti Rule 1* summarized by Sean Carroll in the book by the same name:

Serengeti Rule 1: Not all species are equal. This rule proposes that some species exert effects on the stability and diversity of their community that are disproportionate to their numbers or biomass. These are termed “keystone species” based on the magnitude of their influence on the food chain.

We have applied this biological rule to create a rule for the emerging supply chain network ecosystem.

New Supply Chain Rule 1: Not all enterprises are equal. Firms that adopt more quickly by embracing *real-time data, velocity, transparency, and rapid response* to change in the ecosystem will adapt more quickly, and will survive. Those that do not adopt these principles will become extinct. Hyper-reactive and predictive supply chains have a competitive advantage.

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Companies need to influence their supply chains as a responsibility. Every company has a supply chain and they need to know their position in it and play their position.

Why is velocity and real-time transparency so important in the supply chain? There are many reasons, but an anecdote Tom told me in our first meeting made it very clear.

I was driving alone, stuck in traffic when the three lanes of the 101 were blocked, with an empty HOV lane next to me. There was a fifth lane used by police cars and fire trucks, who ripped off toward the accident which was blocking the highway. I wasn't allowed to use the HOV or police lanes, but it suddenly made me think: rather than trying to weave in and out of traffic in the blocked lanes, it would be much faster to get into a lane that is moving quickly, which would mean adding a passenger. And the analogy was clear: rather than focusing on how to optimize the constraint through lean manufacturing and six sigma, why not just change the game so you can move quickly? And if you focus on speed by thinking differently, then you can go around constraints and won't have to pass through them. So now when people come to my office and tell me about some supply chain problem they're having, my response is to just keep the momentum, switch to the HOV lane, and move quickly around the problem!

This analogy points out a simple concept: in the new global era, *speed and velocity are more important than everything else!* Speed drives business value and inventory turns, reduces working capital, produces cash (monetizes) assets, and makes customers happy, which in turn further drives top line revenue (see Table 1.2). Supply chain optimization typically involves turning the knobs on a supply chain design that is broken. But creation of real-time supply chains provide a means for creating value that the customer cares about, and in today's rapid environment, velocity has customer value. Late deliveries, substandard quality, safety incidents, damaged shipments, and multiple other problems do not alleviate the benefits offered to a customer for lower price, as many logisticians and planners will tell you. In many cases, speed not only reduces costs – it also creates customer value (Table 1.2).

To summarize, companies with speed enabled by real-time visibility will see improved customer satisfaction. What customer doesn't want his or her product more quickly? Speed also reduces costs, as agility and nimbleness allow companies to move quickly to address situations that may end up costing them a lot of money. Speed also reduces inventory, as working capital moves more quickly, and reduces obsolescence and excess inventory. Inventory is a substitute for lead time, so as lead time shrinks, so does inventory. Finally, speed frees up cash flow in a firm's global operations. Companies with more cash flow can reinvest in the business, acquire another company, or buy their stock. All these

Table 1.2 Speed Wins! Pros and Cons of Speed

Pros	Cons
Customer satisfaction improves as revenue is increased	Quality issues may occur through speed
Profits rise as more goods are produced	Growth is challenging
Assets move faster; improving drives productivity	Risk of making the wrong decision
Net working capital and free cash flow improve	Requires increased information visibility which may be perceived as risky

outcomes make the company stronger, and more able to withstand the challenges of the global ecosystem. As predicted by the New Supply Chain Rule 1, enterprises with higher velocity are not equal to slower companies; they are stronger, more nimble, in better financial health, and growing by leaps and bounds, while the slower firms will slowly go extinct (similar to the health of keystone species as defined in Serengeti Rule 1).

Amazon’s Flywheel Effect

One company that “gets this” more than any other is Amazon. Amazon not only developed the world’s largest online marketplace, but has moved to create features like Amazon Prime that promise free shipping in two days. Speed is continually being improved on, as Amazon seeks to create same-day shipping capabilities, to make customer satisfaction even faster. In his book *The Amazon Way*, John Rossman writes about the “flywheel effect.”¹¹ This effect is the opposite of the “bullwhip effect,” a traditional supply chain “theory” that states that rational decision-making based on limited human views of phenomena drive excess inventory in the chain. The flywheel effect is a core element in the rise of Amazon. John Rossman notes, “Allen Mandelbrot founded the field of fractal mathematics, which studies, among other phenomena, how patterns in nature have a tendency to repeat themselves at different scales – for example, the way spiral galaxies resemble whirling sea shells which in turn resemble tiny unfurling fern fronds. In a similar fractal fashion, the virtuous cycle is replicated throughout Amazon.com at macro and micro levels. It generates a set of self-reinforcing energies that continue to flow even when the energy source is discontinuous – much like a flywheel, which is the favorite metaphor for this phenomenon at Amazon.” (p. 8)

¹¹ Rossman, J., *The Amazon Effect*, 2nd ed., CreateSpace Independent Publishing Platform, May 9, 2014.

The flywheel is a metaphor for the emphasis on speed and velocity of decision-making driving flow and interactive speed, or the “anti-control tower” phenomenon. Supply chains are proposed to flow to the point of least resistance, very much like the Chinese proverb that states that cost, like water, will always flow to the lowest point. Similarly, supply chains will always find the fastest way. Route maps have evolved into works of lean architecture in which time is treated as waste, as waste equals cost. The impact of new, responsive supply chains, especially around interactive objects and the “Uber-ization of trucking” poses a radical threat to traditional premium services such as UPS and FedEx, which were founded on traditional point-to-point supply chains with large discontinuities.

Visibility Drives Velocity

Two key concepts reflect the core elements of real-time supply chains. Velocity is the ability of an organization to enable the flow of working capital rapidly through its end-to-end supply chain. Working capital generally comes in the form of inventory, which is an asset that doesn’t produce any revenue or cash. Thus, the object of the real-time supply chain is to achieve velocity in every aspect of how companies run their business. This includes how inventory is tracked and monitored, how much to produce, how much to ship, what modes of transportation to use, how to organize distribution, how to move product through logistics systems, and most importantly, how quickly people in all areas of the supply chain (suppliers, distributors, customers) are able to react and make decisions related to unexpected events and disruptions that impact the supply chain. This is defined by a simple set of principles:

- Real-time data increases visibility
- Increased visibility results in improved velocity
- Velocity increases flow and decreases friction
- Visibility increases prediction accuracy

The key to enabling the ability to have velocity is through visibility – defined as the relative transparency of events, material, and flows to all key decision-makers in the extended supply chain. Visibility allows individuals to see what is going on, and in empowered ways, allows these individuals to interpret information and rapidly make decisions in response to data. The opposite of visibility is opacity, which refers to a complete lack of visibility regarding what is happening in one’s upstream and downstream network. When individuals have visibility that results in velocity of decisions, the system becomes frictionless. Speed of decisions increases not just the flow of information, but also the flow of materials, shipments, production, and all activities in the chain. This reduces friction, which increases flow. Friction includes all the typical delays and problems that slow flow and cause inventory to build up. This includes multiple layers

of approvals, delays in decisions until more information becomes available, or even operating as normal when a major disruption has occurred unbeknownst to you. It can produce bottlenecks in production systems and shipments, which delays material and causes inventory to build.

These principles are not new. Many of the concepts around “lean production systems” emphasize flow and visibility. However, in the context of the digitization of the supply chain, these concepts have a new meaning and impact. It is also the case that many organizations have invested in very expensive systems called “control towers.” In a control tower, information from all of an organization’s logistics systems, production facilities, inbound shipments, outbound shipments, and inventory levels are dumped into a massive data warehouse. The information is then centralized into a “control tower,” where individuals scan what is going on, and senior executives “call the shots,” sometimes using complicated algorithms and automated ordering systems. The fundamental assumption behind control towers is that the people at the top “know best” on how to optimize the entire supply chain, because they are the only ones who have access to all the data. Much of the data pulled are from ERP systems, transportation management systems (TMSs), warehouse management systems (WMSs), distribution requirement systems (DRPs), and material requirement planning systems (MRPs). Because many of these systems are in a “batch mode,” which means they are updated on a weekly, or perhaps daily basis, the information being viewed in the control tower is always lagging. As a result, decision-makers in the control tower are making decisions based on what happened a few days ago, and are determining what to do next, based on what they think will happen next. This scenario embodies the “old” themes of “supply chain integration”: batch processing, information updates, “control-tower” thinking where only some people see the information, and decisions requiring signoffs by the “higher ups.” Linton notes that

Real time supply chains are the anti-control tower. Real-time visibility of information is a driver of velocity, and the two are linked in business and the supply chain. Think about visibility in the context of driving your car. If you are watching your speedometer, you don’t want information on your vehicle’s velocity from a week ago, an hour ago, or even a minute ago. You want to know how fast you are moving right now! The same principle applies to the supply chain. To make informed decisions based on insight pulled from data, we need the data to be as fresh and as current as possible! In this way visible real-time information drives increased supply chain speed.

Traditional enterprise software accumulates silos of data. Managers call upon this data and pull it up in reports that can be used to make decisions. It provides information in chunks or batches, which, by definition, are historical. In fact, almost all decisions in current supply chain systems are based on information

about things that happened in the past. It's as if your car speedometer told you how fast you were going yesterday. This is our current scenario. We know how much we quoted, sourced, contracted, and paid yesterday. What if we could make all our decisions in real time? What would happen to our performance if we had data in real time?

The opposite of flow is friction. Friction occurs when layers of decision-making are introduced into a process, slowing it down. Friction also includes disruptive events, or workers that don't feel empowered to make a difference in their operation, or who feel pressured to say and do things that they don't agree with. Flow is not just about material, it is about the enablement of individuals who work in the entire supply chain to contribute their ideas, thoughts, and observations to their work, with the end customer in mind, and who are allowed to provide feedback and shape the outcome in a positive way.

Visibility is only possible to the extent it is today because of the evolution of technology. Clearly, the establishment of the Internet led to the explosion of information and the subsequent supply chain tools and applications that are now harvesting data, and leading to the evolution of "cognitive" computing. But the disruption has not yet fully matured; in fact, it is only beginning. As organizations begin to operate entities that mediate impacts that are upstream and downstream, the power of this force will become evident as those companies who understand how to deploy this approach survive and thrive.

I had heard this sentiment 20 years ago, when I was working at Michigan State. At the time, Dave Nelson, the CPO of Honda, shared with me a vision that stayed with me for many years.

Think of the number of individuals working in Honda's supply base. Say it's 20,000 people. What if we were able to get each of those 20,000 individuals to go to work every day, and be thinking about how to make Honda's products more innovative, how to improve quality, how to improve flow, and how to be more efficient at doing it? Think of the collective power that resides in the gray matter between the ears of 20,000 individuals, all working toward making Honda better! How can we harness that force!

As those organizations who grasp the viability of this approach expand their approach to influence the ecosystem, the ecosystem will thrive. Enabling people through visibility drives velocity which drives flow. But do people intervene when friction is present? It depends.

Changes Driving LIVING Supply Chains

A focus on speed is essential to the real-time supply chain. Every action should be focused on driving increased velocity of materials through the system.

Linton notes “I tell my people, if you wake up and go to work, and are confused as to what you should focus on that day – focus on speed. Speed will drive all other financial benefits that we need to be paying attention to. It will drive up customer satisfaction, as customers get their products sooner, and get new innovations that come to market sooner. It will drive out excess inventory, and improve our balance sheet. And it will speed up our cash-to-cash cycle, which makes our shareholders happy.”

Tom recalls that this wasn’t always the case. “This is my fifth year at Flex,” he said. “When I arrived, lead-times were in excess of 40 days, in some cases. We set a goal for everyone of getting our lead times to under one month. Through our real-time information efforts, we’ve cut many lead-times by 25% or more. Because the focus in the electronics industry is on shipping everything at the end of the quarter, production is always heavier at the end of the quarter. But if you think of a quarter being only 12 weeks, and recognize that the material can drive 75% or more of your revenue, you need to plan lead times with the ability to pull material quickly. We have a big problem if they don’t align. Speed is essential when moving materials. If the material is not in a supplier management inventory (SMI) hub or Kan Ban, we can’t get material in time to drive revenue. The opposite of this kind of integration is guessing what you think the customer is going to do, and when they don’t do it, you are stuck holding all this inventory. So velocity is the only way to be agile.”

Important issues follow from the principle of emphasizing speed in all areas of the supply chain.

1. The first is that the *centralized control tower is giving way to a new layer of capabilities*. It’s now a mistake to “control” a supply chain – which by definition means to introduce a series of decisions that limit its performance. We need to rethink what we mean by control towers; so we add visibility to increase velocity and not add decision-making gates to slow things down. Supply chains are becoming more virtually vertical, which means that as we become more reliant on our partners, we need to create a virtual form of vertical integration. This boils down to dramatically increasing the connectivity we have with companies in our supply chain. If you look around, there is a flattening of labor costs, which means that the only way to drive down total cost is through regionalization, through regional or local sourcing. This also drives down an organization’s carbon footprint, by reducing transportation output. Whole Foods has the same idea when they use regional sources of produce, seafood, and meat.
2. The second big change that is coming is that *cloud computing is becoming the singular most important component of running a global supply chain*. Cloud computing is allowing something very special to happen, which I like to call business process convergence. In the past, we automated separate business processes that were each operating with one another based on commercial

invoices, purchase orders, and transactional documents. As these automated processes now start to link with one another in the cloud, these traditional transactional documents become obsolete. If you have a strategic supplier with a life-long contract to produce for you, and you know how much you are paying them per unit of output, why do you need a purchase order? You simply pay them electronically as products are shipped in the chain.

Cloud computing allows for the various steps in the business process to be linked in a single view, from multiple companies in multiple devices (mobile). As Cloud computing gets faster and software is developed to optimize for intercompany transactions, supply chains will find new ways to add layers of transparency to traditional business processes.

3. The third big change is that labor arbitrage will no longer be relevant, and that raw material costs and oil prices will eventually go back up. When this occurs, proximity will gain new advantages as commodities held up in long global supply chains will cause balance sheets and other logistics costs to rise. Global labor costs are quickly becoming regionalized, in that manufacturing will increasingly also become regionalized. That's why we believe manufacturing to satisfy demand in North America will return here, as manufacturing for China and Asia will stay over there. The same scenario will hold for the European continent. Because all labor costs will eventually become equal, we are running out of places to find lower cost labor. By the same token, there is a limited quantity of raw materials, whether you are talking about rare earths, metals, or precious metals. Because of the growth in population, demand will go back up, there will be scarcity, and costs will go up. We are in a "golden time" of low oil and commodity prices – but it is only a matter of time before they go up. Our only solution in the end will be to find alternative raw material sources, including bio-based fuel and other products, as well as substituting things like aluminum for copper. But this will take time and engineering.
4. The fourth big change is that *unpredictability is the only thing that is predictable*. Risk is always present and will introduce itself in unpredictable ways. Which means that we need to be more influenced by the use of tools that respond to unpredictability. Tom said, "I recently spoke at MIT and I challenged the engineers to come up with algorithmic models that could better forecast disasters. Now once they occur, we are able to react quickly within less than 24 hours. But forecasting when and where these disasters will occur is impossible. But what we can do is to build models that can tell us the disabling network impact of ANY disaster – something called the "Kill Shot." I'll talk more about that later. In our opinion, the focus on disaster response is like quality was 30 years ago. People are trying to predict where problems will occur – and it is pretty much impossible using the standard

probabilistic models that we are applying today. It is like trying to improve product quality by inspecting every PC we made, instead of designing products for quality.

5. The rise of real-time information allows for enhanced predictability from live visibility. This is one of the reasons Flex created the Flex Pulse Center. It is designed to create a model to take both physical and information latency out of the supply chain process by using real-time information around exception-based management to improve operational outcomes. The system should let you know when you are over your minimum order quantity – and creates a signal to the pulse center. This is like a tire pressure light on your car that only lights up when something is wrong. You have to be notified if there is a problem in your supply chain, whether it's a late delivery, a quality spill, a capacity problem, a transportation delay, a holdup at customs crossing a border, or even a major earthquake at a site. Your supply chain should run on an automated basis, and people are introduced into it only when needed.
6. The final big change we need is to overturn our entire cultural and psychological mindset when it comes to the supply chain. I recently read *Non-Zero* by Robert Wright, which I consider one of the most important books of the decade. It starts with a premise that the world is NOT moving to a zero-sum game, but to a non-zero sum outcome. For example, when a tribe of Inuit people killed a whale for food, they shared it with all the other tribes. All the tribes were trying to survive, so they formed alliances and states, worked together, and were able to march through time together based on collaboration. I started thinking about it – we need to adopt non-zero approaches to supplier management, if we are all to survive. But then I thought: collaboration is good, but it needs to be in balance. And so you need to ask those you respect, and that deserve it, and that you can trust, to join your supply chain.

For the uninitiated, *Non-Zero* explores the non-zero concept behind game theory, which suggests that over the course of history, zero-sum games are not as common as non-zero-sum games. In the latter case, non-zero-sum games involve collaboration between the parties in an eco-system, and emphasize how parties that work together – whether they're cells from multicellular organisms, multi-village policies with centralized rules, or hunter-gatherer societies – tend to mutually benefit. Wright has a positive view of the world, and suggests that positive correlations in non-zero-sum games produces two winners, and that this occurs in economics a good deal. Wright does not deny the existence of exploitation, but is intrinsically upbeat on history moving more toward win-win than win-lose. This is a fundamental concept underlying the LIVING supply chain. Unless organisms work together as a network with full

information, applying this characteristic we call “trust,” survival in a complex, constantly changing world is not possible.

This doesn’t mean that you don’t compete hard to win. When the ocean supply chain (plankton, fish, sharks, and other predators) is all in balance, it is beautiful. But when you take out one of the predators in the chain, it gets all screwed up, and fish and sharks start to starve and die out. So you need a balanced supply chain, and when you are in a balanced set of relationships, you will all survive.

The Big Change: Driving the Need for Real Time

An increasingly common set of discussions also revolves around the digitization and active tracking of product and materials in the network – and not just in the boardroom at Flex. In conversations with several executives at other companies, we discussed the increasing focus on the digitization of supply chains that were moving toward becoming live, fast, and intelligent. We have also presented this theme in several public and private forums, where the conversation inevitably turns to the need to understand the Internet of Things, in which smart and connected objects are driving the digitization of the supply chain. Here are a few examples:

- John Deere has formed an Enterprise Analytics Leadership Council which seeks to build a strategy for analytics for the enterprise, to provide leadership across the enterprise for analytics, and to identify opportunities for adopting analytics techniques.
- Continental is discussing how automobiles will increasingly be automated and connected to the Internet, resulting in an era of driverless vehicles.
- Drone technology is being explored for logistics, inspection of pipelines, and an increasing number of tasks.
- IBM is rolling out cognitive analytics as a base for creating Watson Buyer Assistant, BlueHound, and other technologies for assisting and eventually replacing procurement buyers.

Clearly something bigger is going on here. The role of supply chains is becoming increasingly important in what we believe is our next industrial revolution. The World Economic Forum is calling digitization the Fourth Industrial Revolution.¹² They characterize it as follows:

¹² <http://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond>

The First Industrial Revolution used water and steam power to mechanize production (~1784). The Second used electric power to create mass production (~1870). The Third used electronics and information technology to automate production (~1969). Now a Fourth Industrial Revolution is building on the Third, and is producing the digital revolution that has been occurring since the middle of the last century. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres. ... The possibilities of billions of people connected by mobile devices, with unprecedented processing power, storage capacity, and access to knowledge, are unlimited. And these possibilities will be multiplied by emerging technology breakthroughs in fields such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing.

But how will this revolution impact multi-enterprise networks of organizations working in the supply chain? How did this digitization manifest itself? The idea, of course was compelling, but how to operationalize this big, fuzzy concept into practical approaches? This is what the analytics council at Deere and other companies were trying to figure out.

Linton thought hard about what was going on here in our discussion at the Pulse Center.

We are at an inflection point in the history of the field. Real-time will change the way we think about operating in a global economy, and how we produce things and interact with them in the digital world. The new supply chain is an interdisciplinary system that is driven by real-time information, and which will transform the way companies operate with one another. We need to make people aware of the importance of how real-time data and information will interact with managers of the future. We want them to think about velocity, not about statistical process control, lean manufacturing, or the theory of constraints. This will also require a new kind of manager – one who is much more savvy about working with data and who is comfortable gleaning information from multiple sources of information.

This was the thinking that led us to begin this book. To begin to think about how digitization can be exploited to drive competitive value, we have concluded that the “intelligent” piece of the real-time supply chain needs to be combined with a number of other cultural values within the organization and with the upstream and downstream supply chain network. A good acronym that captures these

concepts is the LIVING supply chain, which forms the basis for the remaining chapters in this book.

Characteristics of the LIVING Supply Chain

The principles of the LIVING supply chain embody this book's key themes:

Live: Do you have a real-time (LIVE) view of your information?

Intelligent: Are you able to connect the essential leverage points in your network through cloud, mobile, and other mediums to provide a platform for analytics? Can you track the DNA of your supply chain at a part number level, globally? Can the system evolve to link the objects in your supply chain?

Velocity: Is your entire enterprise and network focused on moving assets faster than ever in its history?

Interactive: Is there a common governance structure that defines how observations are translated into issues, how they are monitored and validated, and how they are translated into specific actions and responses?

Networked: Is your multi-enterprise supply chain networked so that a common and aligned view of business priorities and actions corresponds to trusting relationships common to everyone?

Good: Is your network truly good, with a common cultural understanding that transcends borders and views as strong principles integrity, doing the right thing, and being transparent about your intentions and actions?

The idea of a LIVING network is a powerful metaphor for what is going on at Flex. Flex recognizes that the "Intelligence of Things," not the "Internet of Things," is the key driver for change in the new era. The Internet is just the utility that keeps data flowing in the system. The emergence of more automation, 3D printing, hyper regionalization, and omni-channel customer service needs will be explicitly considered within an organization's technology roadmap, with the implicit assumption that these technologies will bear fruit in the next 2–5 years. This is not an unreasonable assumption, as the World Economic Forum predicts a "supply-side miracle, with long-term gains in efficiency and productivity. Transportation and communication costs will drop, logistics and global supply chains will become more effective, and the cost of trade will diminish, all of which will open new markets and drive economic growth."

The idea of an organic, LIVING supply chain suggests that not only is the supply chain an evolving, living organism, but that every product, and indeed every worker who toils in our networked factories, suggests a part number and human genome with endless requirements for transparency, in the same manner that the mining of conflict minerals demands visibility to the *n*th level backward into our material supply chains.

What's Next?

The rain was still pouring down as we stepped out of the building that morning.

“Oh, and there is one more big change,” Tom said. “We are going to need increasingly specialized skills for people working in the supply chain. Generalists won’t cut it anymore. We need people who have deep knowledge of procurement, analytics, logistics, transportation, computer science, databases, and other unique skill sets. Because we can’t teach people these things – they need to know what to do when they come out of school.”

“But I also believe that the best soup has a lot of ingredients,” he said. “Too much pepper, and it doesn’t work. So I like to mix up students we hire from different schools, and like seeing people from different backgrounds and genders. Otherwise, if you are too similar in recruiting, you get a certain way of thinking that leads to bias. And in most cases you need people from different places – someone from North Carolina, someone from Brazil, someone from Eastern Europe. Skill-building is something I love to do. I just brought in an Eastern European I met in one of the sites to be my director of the Pulse Center. I gave him the title Vice President of Real Time! Let’s go meet him!”

We walked out into the drizzle of what was supposed to be sunny California. The Super Bowl stadium was in the distance.

