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SUPPLY CHAIN MANAGEMENT REVIEW

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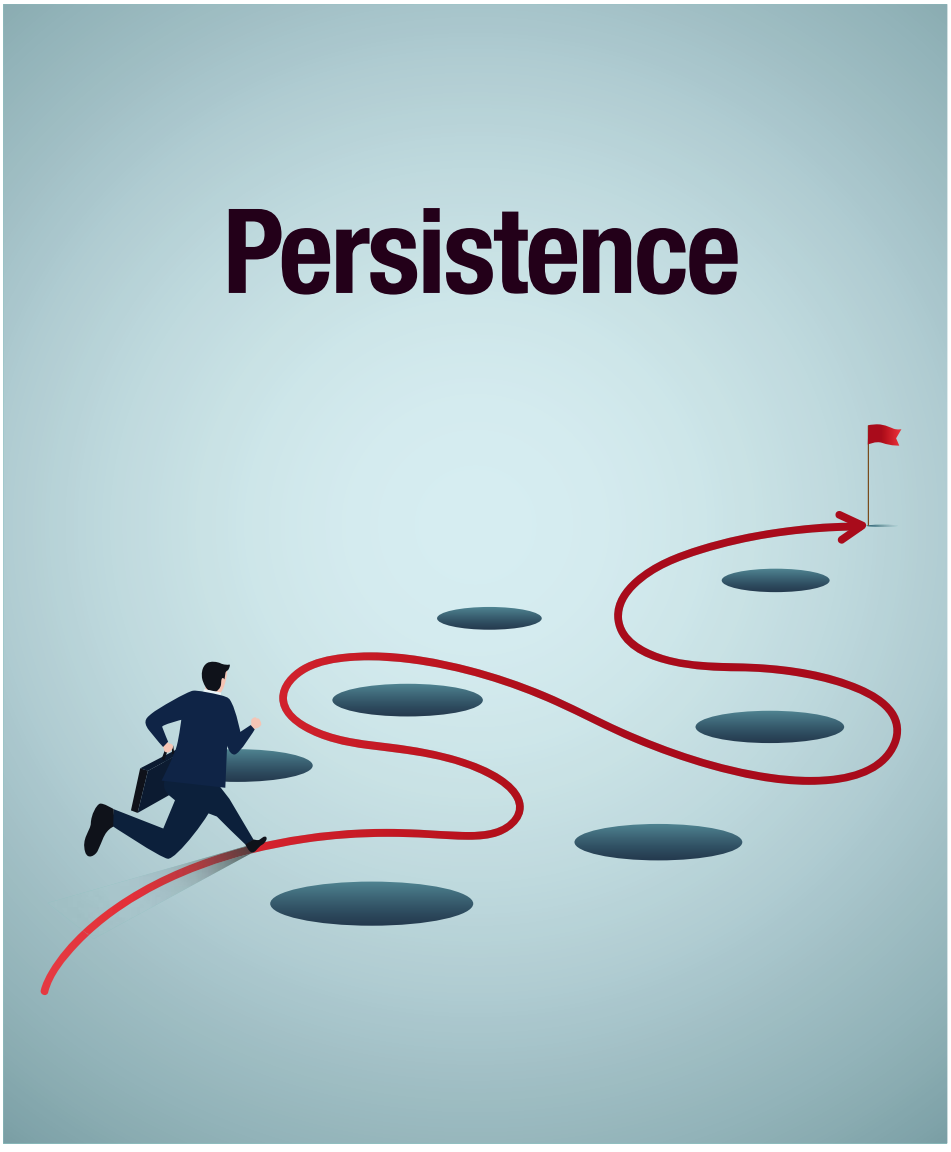

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Hello, my new family

In June 2013, Frank Quinn stepped down as the only editorial director *Supply Chain Management Review* had ever known. "In thinking about those whom I'm indebted to for the success of *SCMR* over 16 years, there is one constituency that must rank first on the list—you, the reader," Frank wrote, as he handed over the reins to Bob Trebilcock.

Now, Bob has done the same, handing over the reins to the next generation. I am very proud to be that next generation. In a farewell letter of sorts, Bob wrote that he was the "old" and I was the "new." Nothing could be further from the truth. There is no old or new, only continuity. That continuity is the backbone of our commitment to you and one that I intend to uphold as I carry on the fine tradition Frank started in 1997.

If you are a friend of Bob's, he remains actively involved during his "semi-retirement," leading Peerless Media's NextGen Supply Chain Conference; attending industry events and writing about materials handling automation for *Modern Materials Handling*.

Myself, I've been fortunate to have had a career that has given me the opportunity to interview governors and presidential candidates, write about college and professional sports, and eat dinners in European castles (yes, the food was pretty good!). And for the last 15-plus years, I've had the opportunity to learn from some of the best minds in the trucking, logistics and supply chain industries.

Brian Straight,
Editor in Chief
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In most issues, this space will be dedicated to providing intelligent insight (I hope) on the supply chain issues of the day. But today I felt it was important to introduce myself, if even only briefly, as your new steward of *Supply Chain Management Review.* I've communicated with some of you already, but if we haven't connected, our time will come. If you would like to reach out in the meantime, my door is open. Reach me at bstraight@peerlessmedia.com or 774.440.3870.

They say industries are like families. The supply chain is certainly that, which is why the best way to continue honoring the history of *SCMR* is to continue down the path that Frank Quinn carved out in 1997, and Bob Trebilcock so ably continued on for the last 10 years. *SCMR* will always remain dedicated to you, the reader, as it has for more than a quarter of a century.

And one last thing: Let's make Bob happy and all register for the NextGen Supply Chain Conference at nextgensupplychainconference.com. This year's event will be held Oct. 16-18, at the Chicago Athletic Association and will feature top executives showcasing current and coming technologies and processes that are transforming the supply chain.

SUPPLY CHAIN MANAGEMENT REVIEW

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LEVERAGING STANDARDIZATION FOR LABORATORY SUPPLY COST MANAGEMENT

By Drew Preslar, **AVP of Supply Chain Solutions, HealthTrust Performance Group**

Managing laboratory supply costs across a health system can be a complicated undertaking. An experienced partner such as HealthTrust Performance Group (HealthTrust) can help systems establish the right internal processes and structures to act strategically, while developing contingency plans to navigate through potential disruptions.

HOW TO NAVIGATE STANDARDIZATION TO MANAGE LABORATORY SUPPLY COST

Standardization of lab equipment and supplies is a large area of opportunity to manage costs. This requires a long-term strategic plan with a focus on laboratory resources including capital, equipment and talent. Health administrators and operators are sometimes reluctant to take on this challenge as it seems burdensome or complex.

However, the benefits of standardization are numerous, including increased cost savings, operational efficiencies, workflow optimization and more. In addition, the process itself can be facilitated by bringing in a partner with deep laboratory experience that can navigate equipment complexities and costs, allowing health system administrators to focus on managing their operations.

At the core, there are a few primary considerations and initial steps to help build your equipment standardization strategy. This involves understanding your current equipment inventory, including useful life, maintenance history, and utilization in addition to creating a catalog of your contracts across categories, including terms and expiration dates, to discover opportunities for consistency and inform long-term planning goals. You should also develop your market strategy to determine where tests will be performed internally (e.g. hub and spoke) and externally (e.g. reference labs) so you know how much equipment you need and where it needs to be. Lastly, identifying current supply shortages and potential global disruptions will help mitigate any future challenges with standardization. This can be done by leveraging the knowledge of an experienced partner.

When taking these steps, you know the equipment your laboratory needs and when the right time to replace it will be. In addition, doing this legwork at the beginning will help streamline the process and feed into your strategy for each category as you work toward standardization.

WHY YOU SHOULD PARTNER WITH HEALTHTRUST

HealthTrust will tailor its services to meet your needs and enter the relationship as a partner rather than a vendor. In the laboratory space, HealthTrust can help your hospital or health system establish a strategic plan, walk side by side through implementation, and develop tools to track progress. HealthTrust will partner with you to take a proactive approach, as well as develop contingency plans, with goals to prepare your system to respond and address any issues that may arise in the future.

HealthTrust has proven expertise and is committed to developing a strategy that is customized for each health system. There are many options to structure agreements that will help upgrade lab instruments and further standardization initiatives, and HealthTrust's experts are the best at reducing costs and minimizing risks with contracts that fit your needs.

Now is the time for hospitals and health systems to minimize laboratory supply costs and risk by exploring partners like HealthTrust. I'm glad to discuss these issues with you directly. Please feel free to contact me at **Drew.Preslar@healthtrustpg.com.**

DREW PRESLAR BIO

Drew has more than fifteen years of experience working in health care systems delivering operational improvements, cost reductions, and process redesigns within Supply Chain Solutions, Surgical Services, and Pharmacy Operations. Prior to joining HealthTrust, Drew spent 4 years at Deloitte Consulting identifying and implementing complex cost savings initiatives for large IDN's. Drew has his MBA from the Fuqua School of Business and his undergraduate degree from Duke University.

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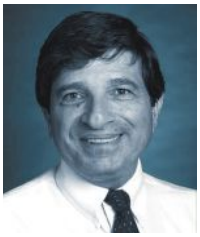
Oil update: We need security plans from policymakers

The business world needs less uncertainty and more clarity.

Dr. Lapide is a lecturer at the University of Massachusetts and an MIT Research Affiliate. He has extensive experience in industry, consulting, business research, and academia as well as a broad range of forecasting, planning, and supply chain experiences. He was an industry forecaster for many years, led supply chain consulting projects for clients across a variety of industries, and has researched supply chain and forecasting software as an analyst. He is the recipient of the inaugural Lifetime Achievement in Business Forecasting & Planning Award from the IBF. He welcomes comments on his columns at llapide@mit.edu.



This is my annual update on oil that began with my first Insights column: "Is your supply chain addicted to oil?" (Jan./Feb. 2007). Since, I've focused on the price of oil because freight costs are a sizable (and controllable) portion of supply chain costs. Also, because it appeared that oil prices would rise over time, it was obvious that supply chains would have to be more energy-efficient and much less dependent on oil. Initially the tagline was "supply chains needed to slow down" because highly responsive chains were energy inefficient. Furthermore, once there were climate concerns, oil got a "dirty name"—as a polluting CO_2 fuel—that became another important reason to squeeze oil out of supply chains.

My last update asked: Where's the plan?

The last oil update was titled: "Oil update: Where's the global energy plan?" (Jan./Feb. 2022). In it, I was concerned that there appeared to be a lack of a coordinated global energy strategy to wean economies off their addiction to fossil fuels. I came to this realization after watching an interchange between host Fareed Zakaria and Tom Friedman, a *New York Times* columnist, on CNN's GPS show (Oct. 10, 2021). They discussed Mr. Friedman's column, "A Scary Energy Winter is Coming. Don't Blame the Greens" (*New York Times*, Oct. 5, 2021). It included a discussion about the fact that natural gas prices were up 500% in Europe, and up worldwide as well.

My understanding (up to that time) was that there was a tacit agreement that there was a global strategy to move away from fossil fuels, by first using natural gas as a bridge

fuel to replace almost all coal, and then oil use. Eventually replacing natural gas with renewables and other non-polluting energy sources.

Yet for decades developed economies, including the United States, Germany and Japan, dropped the ball on the opportunity to develop safer non-polluting nuclear energy. Germany in particular was in the process of dismantling its nuclear power plants and by and large replacing them with natural gas from Russia. Meanwhile, progressive climate activists were pushing against the use and development of fossil fuels, including new pipelines. China and India continued to increase their use of coal as a cheap energy source to provide a better quality of life for their growing citizenry. Over these past two decades the world's population increased from about 6 billion to a current 8 billion, on a possible path to nearly 10 billion by 2050 according to the United Nations, further increasing the use of fossil fuels for a very long time. I believed that no country's energy plans were well-thought out.

Since the Russian invasion, a panic

There is a Yiddish adage, "Man plans, and God laughs;" a version of "the best laid plans of mice and men." Germany learned this important lesson on Feb. 24, 2022, when Russia invaded Ukraine. It was apparently planning to effectively weaponize its natural gas to rebuild the Russian Empire. Countries that were reliant on energy imports scrambled to find alternative sources of energy after banning Russia's energy. Energy prices shot up and consumer prices did as well. The United States tapped into its Strategic Petroleum Reserve (SPR) to help mitigate increasing gas prices at the pump. Germany cancelled its deal with Russia. As I write this article, the *Wall Street Journal* reported climate-activist Greta Thunberg was being detained by German police. She and other demonstrators had reportedly blocked the front of a coal mine being revived over concerns about possible natural gas shortages. (Thunberg was released a short time later.)

In mid-2022, Daniel Yergin, a well-respected energy guru, wrote an op-ed article, "The Global Search for Energy Security" (*Wall Street Journal*, July 6, 2022). The tagline read: "As inflation soars, the West is finally getting serious about a goal it abandoned years ago."

Zakaria and Friedman had a similar discussion on CNN's GPS show months later (Oct. 10, 2022). They discussed the Russian invasion and its impact on energy. However, they started the program talking about the fact that an energy plan was not sufficient to help the world move toward carbon-neutrality. To get there, there needed to be three coordinated and balanced plans to achieve: "energy security, economic security, and climate security." Hence the title of this column.

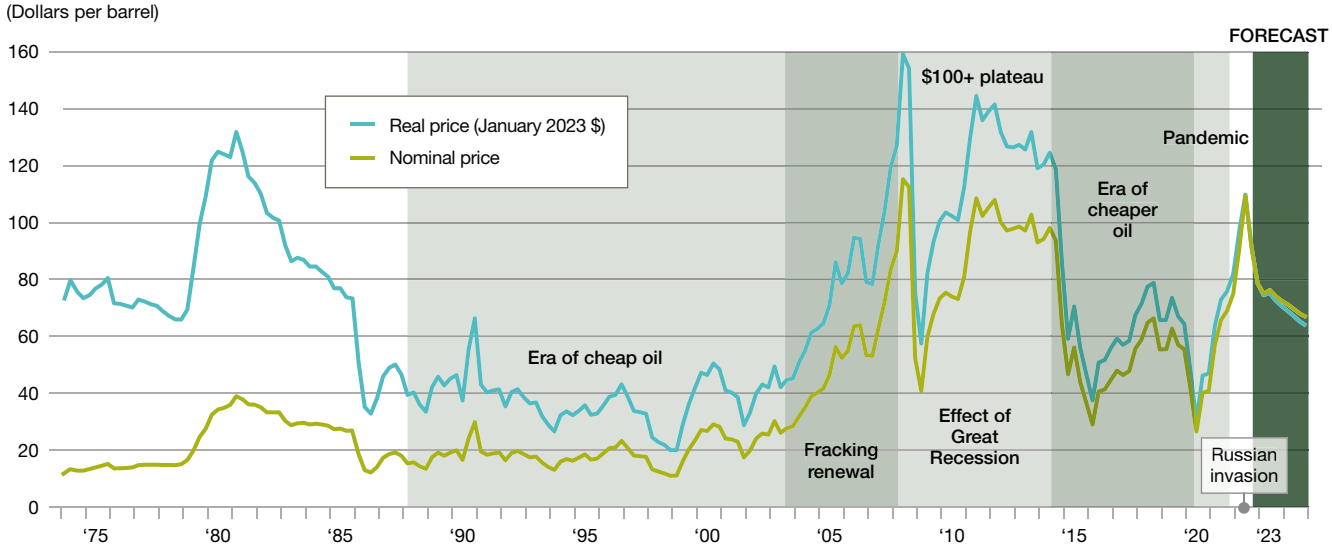
A brief history oil pricing

In each oil update I've shown Figure 1, an updated historical chart depicting real quarterly imported crude oil prices since 1974. The chart shows various pricing levels experienced. After the "era of cheap oil" ended with rising prices, the first signs of cheaper oil appeared as a precipitous drop, the result of the Great Recession of 2008, which drastically depressed worldwide economies and the demand for oil. This was followed by a three-plus year period,

FIGURE 1

Quarterly imported crude oil price

(Dollars per barrel)



Source: EIA Short-Term Energy Outlook, January 2023

termed the "$100+ plateau" before reaching cheaper oil. The $100+ plateau ominously looms in the rearview mirror as a reminder of what could happen if worldwide economic and supply conditions reach the robust levels seen prior to the recession.

Over the period of higher oil prices, U.S. oil fracking operations came online because the prices were high enough to economically justify them. U.S. frackers used the opportunity to innovate to reach a point where operations were flexible enough to easily turn on and off as oil prices went up and down. The fracking industry made the United States the world's top oil supplier and a net exporter. In addition, fracking output caused a worldwide oversupply of oil that kept the era of cheaper oil going. However, as discussed in my 2021 update, oil prices dropped to cheap oil levels when the pandemic began—prices not seen since around 2004. I questioned whether fracking was still economically justified.

As seen from Figure 1, the Russian invasion triggered a spike in prices. However, it seems short lived, peaking to over the $100+ plateau for only one quarter and might level back down to cheaper oil.

The past year in the news

Faced with uncertainties due to climate change, the lingering pandemic, and the Ukraine-Russian war, policymakers have been in a tizzy. The history of climate change initiatives shows there had been too much focus on diplomatic solutions. Yielding largely broken (unrealistic) promises by countries.

Since 2021, frackers have been less of the story—after having broken the back of OPEC's hold on the oil market. Frackers have been trying to figure out how to sustain their businesses under cheaper oil pricing. As shown in Figure 1, cheap oil pricing was short-lived, and largely a result of the drops in demand from the economic impacts of the COVID-19 pandemic. In early 2022, there

was an article published, "Frackers Hold Back Production as Global Oil Market Tightens" (*Wall Street Journal*, Feb. 19, 2022).

Yet, almost a year after the Russian invasion, an article ("Oil and Gas Are Back and Booming." *Wall Street Journal*, Jan. 11, 2023), heralded the return of oil and gas. Apparently, there is plenty of fossil fuel available for a price. It seems the world's addiction to fossil fuels can't be remedied by the weather patterns the world is currently seeing and attributing to climate change. It will take quite a while to wean economies off fossil-based fuels.

There was some positive news about reinstating nuclear as another important bridge fuel to help. A few headlines of news articles were:

- "The Global Nuclear Comeback" (*Wall Street Journal*, July 19, 2022);
- "Germany Rethinks Plan to Close Nuclear Reactors" (*Wall Street Journal*, Aug. 4, 2022); and
- "California Set to Extend Nuclear Plant" (*Wall Street Journal*, Sept. 2, 2022).

There was a very interesting op-ed article in the *Boston Globe* (July 18, 2022) written by Ernest J. Moniz, a professor emeritus at MIT. It was titled "A way forward on the climate crisis and energy insecurity." In it he states: "Oil and gas remain central to global energy systems and are key to energy security, at least in the near and mid-term." (For anyone who does not recognize his name, Moniz was President Obama's U.S. Secretary of Energy). He knows something about the energy picture. Interestingly, instead of getting him to work on climate change and energy security plans, Obama picked him to be part of the U.S. negotiation team on the Iran nuclear deal—focused on developing systems to monitor Iran's compliance. I believe it was a lost opportunity for the professor to pitch his good ideas while he had the pulpit to do so. However, Obama (wisely) focused on shorter-term security, trying to prevent another country from obtaining the capability to build nuclear bombs.

Recommendations

My advice generally stays the same as the past few years. It will always be prudent to reduce the use of carbon-based energy sources by making your supply chains as energy efficient as possible. However, be cautiously on the lookout for serious and harsher Green New Deal initiatives from government policymakers in the future. Given their progress to date, what policies they are is anybody's guess.

Policymakers are having difficulties weaning their citizens away from fossil fuels. Why? Because these fuels—in solid, liquid, or gaseous form—can be easily transported and stored to where energy is needed. Meanwhile, the biggest issue with renewable energy—wind turbines and solar panels—is that they are intermittent sources of energy. Electricity gets created only when the wind blows and the sun shines. Not necessarily when and where there is demand for energy. Thus, their energy needs to be sold to an electric grid, or if not wanted, stored or used to make non-carbon fuels. The technologies to do this on a large scale are nascent at best and require massive uncertain innovation. The reality has been that renewable innovation has not kept up with the still-growing thirst for fossil fuels.

The business world needs less uncertainty and more clarity. We can only get that when policymakers finally develop three coordinated and balanced plans for energy security, economic security, and climate security. These will be likely be developed later, rather than sooner.

Exorcising ghost lanes from transportation procurement

Procuring freight transportation is a well-established supply chain process, yet the pervasiveness of ghost lanes as a consequence of "coverage" procurement strategies is little understood or appreciated.

By Angela Acocella

Angela Acocella is a research affiliate at MIT CTL and a postdoctoral researcher at Tilburg University. She can be reached at acocella@mit.edu.

Ghost lanes are freight lanes contracted to motor carriers that are never used by the shippers that procure them. Research carried out at the MIT Center for Transportation & Logistics (MIT CTL) shows that contracting with carriers to move cargo that never materializes is far more prevalent than is widely assumed and exacts a surprisingly high price for both shippers and trucking companies.

We built a predictive model to identify which freight lanes are the most likely to yield very few or no loads, to estimate how much this outcome costs shippers, and to identify ways the industry can eliminate this profligate practice. Addressing the ghost lane issue may mean changing deep-seated behavior patterns.

Multiple pain points

We analyzed a large data set of shippers' procurement outcomes and found that about 70% of the lanes procured in a given year end up as ghost lanes in that year. In other words, some 70% of the procurement process for motor freight—a complex process that can take many months to complete—was not needed.

Every participant pays a price for such extravagance.

In addition to shouldering unnecessary administrative costs, shippers incur higher freight costs. We modeled carriers' behavior year-over-year and found that carriers burdened with relatively high numbers of ghost lanes tend to increase their prices for the shippers involved. Our research indicates that for every 10-percentage point increase in the number of ghost lanes a carrier takes on in a given year, contract prices for that shipper increase by 1% the following year. This means that on average, shippers see 7% higher contract prices the next year than they would have without such high ghost lane rates.

Motor carriers waste time and effort bidding for business that does not exist and fail to earn the revenue associated with these lanes. Also, allocating trucks to carry phantom cargo can create network imbalances that make it more difficult for a carrier to compete in potentially profitable lanes. Such imbalances can also lead to an increase in empty miles, making the network less efficient and less sustainable.

Consumers can also suffer the adverse consequences of ghost lanes when escalating freight transportation costs result in higher product prices.

Picking zero-load lanes

Why do shippers engage in such a seemingly needless and wasteful exercise?

In general, shippers make a strategic choice to include these lanes in their procurement events to hedge against demand uncertainty. We call this a coverage approach to procurement. Carrier capacity is procured a year in advance, and shippers do not know for sure what volume of orders they will need to move. There are many possible ways in which a shipper might underestimate future volumes. For example, perhaps a new warehouse did not receive the volumes projected by the company, or a customer failed to place the orders anticipated.

Faced with such ambiguities, shippers include lanes with a low probability of yielding cargo in the bid process. They want to make sure that contract rates from known carriers are on file in

case demand picks up in these lanes. Also, shippers want to minimize the likelihood of having to resort to the spot market to find capacity.

Can lanes likely to fall under the ghost category be identified ahead of a procurement event? To answer this question, we created a predictive model that analyzed lane characteristics and the profiles of ghost lanes. The model confirmed that these lanes can be identified.

First, a lane's newness is the strongest indicator of its potential to become a ghost lane. Lanes not included in the previous year's bidding exercise are prime candidates. We found that 85% of ghost lanes were not included in last year's procurement event.

In addition, lanes procured the previous year that failed to yield loads exhibited the same tendency the year before that. It appears that ghost lanes typically recur year after year, so they can be detected by checking past performance.

The model indicated that the ghost lanes that were not new—that is, those that had been procured the previous year—were often low volume in the past. Also, lanes characterized by high geographic aggregation levels—for example, region-to-region or three-digit zip code-to-three-digit zip code—are more likely to become ghost lanes. Such broad aggregations often lead to lane duplication that results in very low or zero load volumes on some lanes.

Addressing the problem

If the ghost lane problem is so prevalent, what can be done to address it?

The most direct solution is to identify lanes that are prime candidates for meeting the definition of "ghost" and remove them from procurement events. Maybe these lanes can be procured in separate mini bids if the shipper is adamant that it wants contract rates for this business. Or the loads could be put out to bid if the business materializes. Alternatively, if the volumes are very low then perhaps using the spot market to acquire capacity in these load-deficient lanes is not such a bad idea.

An obvious argument against these solutions is that they expose shippers to the uncertainty-related risks that ghost lanes intend to mitigate. However, after considering this argument in detail, we concluded that the ghost lane risk management strategy may not be as effective at shielding shippers from capacity and price uncertainty as is assumed.

Based on our research, some 95% of new lanes in a given year become ghost lanes. It follows that only about 5% yield loads for the carrier. We looked at carrier acceptance rates on this small group of lanes and found that about 73% of the loads tendered are actually accepted. This is an unacceptably low number given that shippers generally expect acceptance rates for motor freight of 95% to 99%.

These figures suggest that including new lanes in bids is not an effective hedge against demand uncertainty, because even when loads materialize, a relatively low number are accepted by carriers.

We also explored the contract prices offered by trucking companies that accept loads on these new lanes that do see loads. Our research showed that contract prices were 13% to 40% higher than spot prices at the times the loads became available. So, shippers appear to be overpaying for freight transportation on these potential ghost lanes.

In combination, these findings provide convincing arguments for eliminating ghost lanes from procurement events. To address the problem, shippers need to look more diligently at past performance and identify the ghost lanes as well as their underlying causes. For example, how were these lanes defined, why were they included in bids, and what price was paid for their inclusion?

Of course, every distribution network is different and there may be competitive reasons for retaining ghost lanes. However, at the very least, shippers would benefit from gaining a more thorough understanding of how this strategy affects their networks.

Attitudinal habits at work

On a more philosophical level, the existence of the ghost lane issue reflects broader human behavioral patterns.

People prefer to know what their current costs are than guess what their future, unknown costs might be; the devil you know is preferable to the unknown devil. In a freight transportation context, this means swallowing the administrative and extra freight costs generated by including ghost lanes in bids. At the same time, shippers overemphasize the risks that come with future market uncertainty including the challenge of finding truck capacity especially in the spot market.

Another behavioral factor is the high value people put on flexibility. Individuals like to have as many options as possible to offset the risks that come with future uncertainty. Researchers have explored this tendency in controlled experiments. The upshot of this work is that people will knowingly overinvest today to secure more options later on. From a freight perspective, shippers are willing to incur avoidable transportation costs and the effort required to sift through carriers in lanes they may never use to acquire the flexibility needed to ride out future volatility.

We believe there is a need to research these tendencies further. For example, what value do shippers place on flexibility in the freight transportation procurement process, and to what extent do they recoup the costs involved?

The research described above suggests that shippers might be investing in a risk management strategy that does not deliver the returns they envisage.

Research on ghost lanes and related transportation procurement practices is ongoing at the MIT FreightLab.

Additive manufacturing: Shaping and disrupting business models

By Ankit Tiwari and Shivraj Gill

Ankit Tiwari is a director in the Global Supply Chain Consulting Practice at Tata Consultancy Services (TCS) and can be reached at ank.tiwari@tcs.com. Shivraj Gill is a business analyst in the Global Supply Chain Consulting Practice at Tata Consultancy Services (TCS) and can be reached at shiv.gill@tcs.com.

Just imagine that you are building a LEGO rocket ship and you lost a critical engine block piece that prevents you from completing and launching the rocket. Most people have experienced this show stopping sense of frustration, rendering the whole effort futile and the outcome disappointing. LEGO has an online platform that you can search by color, part name, category, and keyword; however, you must wait for LEGO to ship you that one specific piece. In the future, imagine a kiosk in a public place or a nearby coffee shop that will be able to print out that missing part for you to pick up or have delivered to your home. This is the promise of 3D printing, or additive manufacturing technology; no missing LEGO piece can block your imagination and prevent you from fulfilling your vision.

So, just what is additive manufacturing?

According to the MIT Sloan School of Management, additive manufacturing (AM) is a process used to create an object by building it one layer at a time. The most popular AM technology is referred to as 3D printing (Gartner adds "using a device to create physical objects from digital models") and the technology is evolving and becoming more popular with the "early majority" in recent years. The basic process involves adding layers of raw material in a shape or design that has been uploaded to the printer via a digital link to a computer or wirelessly connected device.

Crossing the chasm

AM is currently used across numerous discrete manufacturing industries; for example, parts used in the manufacturing of aircraft and automobiles, medical equipment, energy, and even printing a wide range of smaller consumer goods. The aerospace industry has been an aggressive innovator and early adopter in implementing additive manufacturing in its manufacturing processes. Subsequently, many other manufacturing industries are also advancing the feasibility and implementation of additive manufacturing. According to Ronan Ye, founder and author of 3ERP, the automotive industry is quickly integrating additive manufacturing into its manufacturing processes; and there are a few large manufacturers that have heavily invested in its future, including BMW, GM, Ford and Volvo, to name a few. These manufacturers are harnessing and leveraging the capabilities of AM to offer customers more personalization options, speed time to market, and reduce logistics and transportation costs and wait times for parts, tooling, jigs and fixtures.

Using the technology for rapid prototyping is changing new product introduction lead time assumptions and processes and is providing a

competitive advantage in prototyping and launching new vehicles and models. New products can be introduced more rapidly at less cost resulting in savings both to the manufacturers and their customers.

Environmental benefits

Additive manufacturing advantages extend beyond potential cost benefits. There are significant environmental benefits inherent in the 3D printing process. These benefits have a very wide scope, from requiring lower emissions to manufacture and transport 3D printed parts due to lighter components, reduced packaging cost and waste, and consolidated materials, to virtually eliminating all waste generated in the manufacturing process. AM technologies enable the part or component being manufactured to be layered with the raw material, common to many other parts, that is fed into the 3D printing machine. Many traditional fabrication processes, such as cutting and shaving the part out of a block of raw material, are eliminated. In addition, any waste produced via the AM process can be melted or grinded down and fed back into the printer for use in the next component to be produced. Companies leveraging AM in the production cycle benefit from sustainable "circularity" in product design for reuse, recycling, and overall reduction in environmental impact.

Supply chain benefits

Additive manufacturing is and will continue to change how numerous industries think about their supply chain businesses and operating models. As an example, there are several medical device firms that are now able to personalize and print various size products identified during the surgical procedure, thereby reducing the "trunk inventory" that manufacturer product support representatives must carry for different size products that must be available for the custom fit to the patient. An example are hip implants that are printed and stimulate bone growth through porous internal structures. Using traditional manufacturing methods makes it impossible to achieve the same results, thus creating longer recovery times for patients.

Recent changes in the world have placed a massive strain and disruption to many supply chains, especially in production, due to reductions in available raw materials and production capacities throughout market ecosystems. As production and distribution facilities were shut down, product availability was consumed at a rate faster than companies could replenish the demand channels. The supply side has been disrupted as much if not more than the demand side. Lead times on the supply side (raw material, components, etc.) are measured in weeks and months. Conversely, demand side lead times are measured in hours and days, consumers want product on demand. Keeping up with that demand, especially in SKU-proliferated products, has amplified the lead time conundrum from physical distribution constraints of buffers and distance.

Additive manufacturing challenges the lead time conundrum by eliminating certain physical constraints by decentralizing production of the different products in different quantities nearer to the point of consumption. Instead of holding many SKUs for different sizes and brand variations of the same product to meet individual customer requirements, the common materials across the end-product variations can be distributed in bulk and specific SKUs "printed" at the point of demand. Voila.

Postponement in action

Considering a departure from the current business model in the automotive industry, customers could experience little to no wait times when it comes to preventive and aftermarket maintenance services. With company- or privately-owned dealerships and large auto manufacturers working together to build 3D printing facilities that can support multiple dealerships and service centers, aftermarket parts inventory can be reduced and the right part can be printed as needed, leading to shorter wait times and lower costs to customers for parts. The 3D printing service bureau model is well suited to repetitive replenishment of parts to maintenance service shops.

Direct-to-consumer shift

While the manufacturing industries enjoy the benefits of AM, exponential growth possibilities are around the corner with the exposure of 3D printing to end consumers, as indicated in the LEGO example. This shift to direct-to-consumer is changing distribution

channel business models, sourcing arrangements with suppliers, product management and engineering leading to growth of emerging startups that will provide new printing and distribution services. As the cost of equipment comes down and the technology matures, new business models are emerging to leverage the advantage AM technologies offer. The last mile logistics market could be significantly disrupted as product is produced within a mile of the consumer.

Pay attention to new technology hype cycles, adoption curves

Additive manufacturing has numerous benefits including cost savings, easing tensions on supply chains, and environmental benefits such as reduced transportation and production emissions, packaging and raw materials, and the promise of virtually eliminating waste. It can also be used to personalize and print tooling, jigs, component materials, and in some cases, bypass or eliminate supply chains.

The automotive industry has experienced shorter timelines for prototypes and cost savings using additive manufacturing. It is also being used in the construction industry to reduce CO_2 emissions and in the medical field for personalized implants and devices. The peak of inflated expectations for AM and 3D is over and while many companies ignore the trough of disillusionment cycle, the innovators explore business use cases and initiatives that leverage the advantages of new technologies to disrupt current business models. The early adopters pay close attention to the business model changes the innovators bring to market and capture early returns and market share.

Overall, additive manufacturing will be critical to the future of numerous manufacturing industries and evolving business models. Waiting for the technology to "cross the chasm" begs the risk of late adoption and falling off the cliff of the "existential mountain" into the laggard pool to tread water and eventually drown. Been to a Blockbuster recently?

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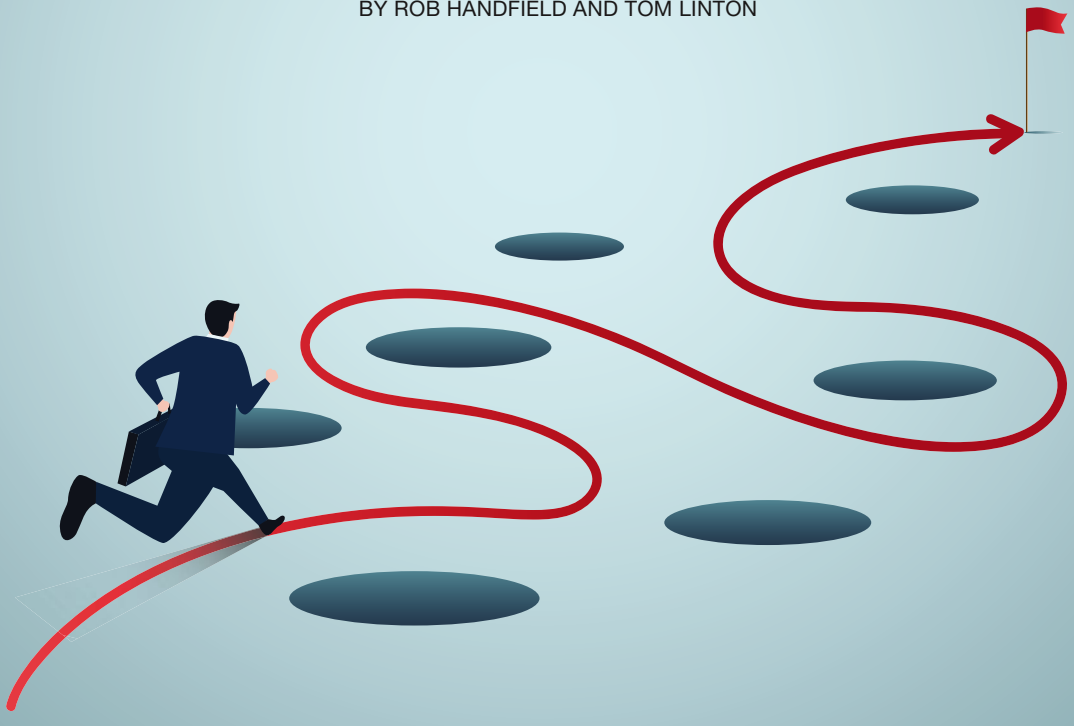
Presented by Peerless MEDIA, LLC SUPPLY CHAIN MANAGEMENT REVIEW

SUPPLY CHAINS FAIL WHEN THEY DON'T FLOW

Disruptions can slow the movement of goods, but they don't have to. Here are five steps to ensure smooth operations.

BY ROB HANDFIELD AND TOM LINTON



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Editor's note: The following article is adapted from "Flow: How the Best Supply Chains Thrive," *which is available from Rotman-UTP Publishing. It is republished with permission from the authors. You can read an excerpt from their earlier book,* "The Living Supply Chain," *on scmr.com.*

In the natural world, we are continuously aware of movement and flows. Snow falls onto mountains, melts in the spring and flows into the rivers, which flow into the ocean. Birds flow from northern hemispheres to southern climates, and then go back again. The tides flow back and forth with the moon, and gravity pulls objects to the center. We learn from natural flows about how things move. In the last several years, supply chains stopped moving. The reasons for this range from the COVID-19 pandemic's direct impacts on production output in China, and material supply chain disruptions, labor shortages as well as unexpected demand surges. All of these have one common denominator: The flow or movement of materials is constrained by their physical design.

What are the barriers that prevent our global supply chains from flowing?

We need to unleash supply chains, not control them

Prior to the COVID-19 pandemic, parts and products flowed quickly and fluidly, navigating their way around barriers to reach their destinations. By applying principles from the physical world, we can reduce the friction that disrupts our supply chains since the onset of the COVID-19 pandemic. But doing so will require managers to rethink their concept of how global supply chains are governed and will necessitate bold investments in technology, tighter supplier relationships, and a change in traditional supply chain thinking.

The principles of flow are grounded in physics, which provide a number of simple and important laws that are irrefutable; these laws determine how fluids, electricity and matter travel. Physical flows are measured using metrics such as speed, distance, electrical flow and other dimensions. But these physical flows can also be used to assess the design and management of supply chains. Drawing from our recent book, we propose a set of five simple guidelines that can be applied to improve the simplicity, efficiency and cost-effectiveness of supply chains.

1. Remove the physical obstacles to supply chain flows.

Thermodynamic laws state that as objects are pushed closer together, the force between them increases. Such principles apply to the goal of moving things using less cost through supply chains.

Consider what happens when water flowing in a river encounters a barrier such as a sandbar, stones or a shift in elevation. The flow of water is redirected to a new channel, seeking the path of least resistance. Over time, the river may adapt and form a completely different channel, etching deep valleys into rock faces. We believe that this is happening today with supply chains: As new obstacles appear, supply chain flows are being redirected to a path that presents the fewest obstacles and the lowest total cost.

Total cost is not the same as the price paid for a product or material. Total cost is the accumulation of price, tariffs, transportation, distribution, cargo fees, packaging and so on. This principle is today being applied to the exchange of goods and services between enterprises that are shaped by trade flows. As ocean freight costs increased in 2021, total cost of shipping from China to the United States exceeded $4,000 from $1,600 prior to the pandemic. And lead times can take 30 days to 40 days, not including a week or more of delays at major ports. This means cargo is sitting for months at a time, leading to increased levels of inventory working capital.

Lower total costs are driving production of products for various markets from Asia to Mexico. They are leading companies to build distribution centers closer to the customer. And they are causing them to redesign products to use more standard components that are more available.

2. Friend-shoring is the new near-shoring.
A company's supply chain design is integral to its competitive footprint. "Near-shoring" means switching to a supplier in a country that's closer to your operations or customers than the one you have been using. "Friend-shoring" is a term coined by the Biden Administration to refer to the offshoring of production to friends and allies of the United States. The last [several] years of tariffs, trade wars, Brexit and COVID are a natural progression of events that have led Western economies away from the low-cost country sourcing strategies of the last 20 years. The reality, however, is that bringing production back to the United States is not easily accomplished—so friend-shoring is the next best thing. One of the most likely "friend-shoring" countries is Mexico, which also has free trade agreements with more than 57 countries worldwide.

Compressing supply chains to locations like Mexico can not only increase inventory velocity and reduce transportation costs, but it can also build stronger relationships through reliable supply and improved communications with suppliers—and not necessarily at a higher price. Shifting supply chains to achieve the benefits of friend-shoring versus the total cost of outsourcing to a low-price locale may be an appealing concept, but the transition to new suppliers in locations such as Mexico will entail a significant investment. Designing the intricate logistics and production requirements takes time, bearing in mind that improved material flow remains the primary consideration. It's a decision that many organizations are evaluating. Ultimately, supply chains will evolve to those market channels that generate the lowest total cost.

Another big barrier to making this transition is the mindset of managers. The focus of many supply chain managers is on obtaining a negotiated cost savings of 5% to 10% on the purchase price, regardless of the price, while failing to observe and take note of the significant changes taking place around them. A few percentage points in price savings pale in comparison when six months' worth of orders can be wiped off the books by a COVID virus or a Brexit event, or when a trade deal increases tariffs by 25%.

3. Visibility systems lead to faster flows.
We predict that the combination of evolving supply chain flows and advancing digital tools will yield a 3X improvement in supply chain performance in the next decade. Analytics will leverage information collected from sensors that transmit data throughout the internet of things, leading to massive streams of intelligence being pushed towards managers. Those organizations that scale the systems used to integrate real-time data flows into decision-making will be able to react more quickly to disruptions in flows. Just like a river redirects its flow when it encounters obstacles, supply chain flows that encounter natural disruptions, whether manmade (e.g. tariffs or trade restrictions) or acts of nature (e.g floods or hurricanes) must be redirected. Visibility to the sources of disruption in supply chains allows managers to "unblock" these issues.

Digital flows enable managers to see when material or cash isn't moving. Quicker movement of material enabled by real-time data flows leads to faster free cash flow, higher revenue and customer satisfaction. Supply chain flows are impacted by friction, barriers, delays and resistance which create disruptions and increase costs. Being able to quickly evaluate and respond to real-time analytics will become the next critical skillset for supply chain managers to master.

4. Preserve the ecosystem that supports free flowing supply chains.
Think of supply chain ecosystems as a huge coral reef. Coral needs microscopic algae (zooxanthellae) to survive. But these algae cannot live above a certain temperature, so as the ocean warms, the algae die. Without

its food supply, the coral also dies. The flow of cooler water supports the entire ecosystem for the entire ocean. Similarly, global organizations have similarly symbiotic relationships with their regional suppliers and are the essential fabric of supply chains.

This means that companies must sustain the suppliers that are the lifeblood of their supply chains. Many suppliers have a limited ability to withstand supply chain disruptions and financial pressures, so understanding their financial and operational health is essential. Even well-capitalized global companies can be shut down when a Tier 2 or Tier 3 supplier fails to ship the "golden screw"—a part that is essential to completing the assembly of the end product, even if it is a low-priced, otherwise inconsequential part like a screw. For example, automotive companies were stuck with months of finished goods inventory they could not sell, often because they did not have the "workhorse" larger semiconductors required for their electronics. It only takes one supplier to shut you down.

Companies are becoming more aware of the fragility of their supply base and are taking steps to protect it. During the early months of the pandemic, Lockheed Martin advanced more than $50 million to small and medium-sized enterprises (SMEs) in its supply chain, and the telecom company Vodafone made a commitment to pay its European suppliers within 15 days.

Understanding the condition of suppliers through a regular open dialogue is important. Some suppliers may not want to disclose their financial difficulties for fear they will be cut off. Some Tier 1 suppliers may object to having their customers reach out and speak to Tier 2 suppliers (which Tier 1 companies think of as their own suppliers). Breaking down such barriers in difficult times is essential. After all, it is the OEM's financial flows that sustain the Tier 1 and Tier 2 suppliers.

5. Explore regional supply chain flows.
Over the past 20 years, Western companies moved almost all their production to China; Chinese wages were lower and operations were efficient. In our post-COVID world, however, Chinese products have become much more expensive; transportation lead times have become longer; and zero COVID disruptions occur more frequently. That is leading some firms to consider a strategy referred to as "make where you sell, buy where you make." The strategy calls for locating production near a firm's customers and developing a local supply base to service production.

While the goal of transitioning to a regional supply chain will not occur overnight, we are beginning to witness multinationals shifting manufacturing out of China. For instance, Apple's new iPhone 14 is being produced in India near Chennai, the first time this has ever happened. And the move to make where you sell, buy where you make is beginning. Many companies that serve customers in Europe, for example, are migrating to Eastern Europe as a source for domestic supply.

This does not mean that China will suddenly lose a large part of its industrial base. China will develop its own regional supply chains, which will benefit its companies, consumers and economy. We believe more U.S. companies will build factories in China to move closer to their Chinese customers, and more Chinese companies will move closer to their U.S. customers. We predict increased regionalization of supply chains closer to their source by 2027. This may be expedited by regulatory shifts calling for localization of critical components for military support, hospital supplies and medical devices as a result of the shortages seen during the pandemic.

A crisis is an opportunity for renewal. This is a great time for supply chain executives to expand their views using the guidelines of flow to influence the shape of the global economy. They have an opportunity to rewrite the playbook, establish a new basis for sourcing products and services and develop a more self-sufficient and resilient network in a post-COVID economy. When disruptions shut down a company's supply chain, it is time to rethink assumptions about how that supply chain is designed. It's time to innovate new solutions to ensure our supply chains can flow again.

CLIMBING TO NEW HEIGHTS

Preparation and visibility build the confidence to scale the supply chain mountain

BY STANLEY E. FAWCETT, MARKUS GESCHBERGER, AMYDEE M. FAWCETT, A. MICHAEL KNEMEYER AND SEBASTIAN BROCKHAUS

On June 3, 2017, Alex Honnold did what elite rock climbers believed to be impossible: He climbed El Capitan, Yosemite's iconic 3,200-foot sheer granite cliff, without ropes. Pushing the limits of human ability, Honnold achieved a personal quest for climbing mastery and elevated sports climbing to new heights. His journey was documented in the Academy Award winning movie, "Free Solo." If you've never heard the term, to free solo is to rock climb without ropes or protective gear. One slip, one wrong move means certain death.

How intense is free soloing? Tommy Caldwell—the man National Geographic called "arguably the best all-round rock climber on the planet"—described Honnold's feat: "Imagine an Olympic gold-medal-level athletic achievement, that if you don't get that gold medal, you're gonna die. That's pretty much what free soloing El Cap is like. You have to do it perfectly." The *New York Times* asserted: "Alex Honnold's free solo climb of El Capitan should be celebrated as one of the greatest athletic feats of any kind ever."

As stunning as Honnold's free solo of El Capitan was, you may be thinking, "What can I, as a supply chain professional, learn from Honnold's ascent?" Pundits have drawn parallels to elevating innovation and conquering risk, key concerns on your radar.

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Honnold, however, points to a more pertinent supply chain takeaway:

When I am doing these hard free solos, I like to think that the risk, the chance of falling is quite low, even though the consequence is extremely high. And that's one of the appeals of free soloing. Take something that appears to be difficult and dangerous and make it feel safe.

Now, a question: Do you ever sense fear, or perhaps apprehension, because of what you can't see across your supply chain? To overcome this fear, follow Honnold's lead. You'll learn how to leverage visibility to make dangerous and difficult tasks feel doable in today's crazy supply chain world.

For Honnold, success on El Capitan began with panic on Half Dome. There, a slab of smooth granite taught him that "preparation is what stops the fear." Let's learn how.

A great climber, not a lucky climber

On Sept. 4, 2008, Honnold came to Half Dome in Yosemite National Park. He had previously climbed the 2,000-foot Northwest Face four times. But on this day, he had come with purpose. His goal: To make a roped free ascent to scout the route—to make sure he knew "roughly where to go" and that he "could physically do it." Two days later, he became the only person to free solo Half Dome. He made the ascent in 2 hours, 50 minutes, arriving at the summit before noon. Amazingly, he was dissatisfied. That night, he recorded his free solo in his climbing journal, concluding with two words—"*Do better*"—followed by a frowny face.

Why was Honnold disenchanted with his historic achievement? On the 10th pitch, he decided to skip one of the hardest parts of the climb, opting instead for a 300-foot circuitous variation he had never climbed before. Quickly, he began to doubt his decision. Wondering if he was lost, he confessed: "I was pretty rattled." Worse, between Honnold and the summit, a difficult and dangerous stretch awaited. He would have to climb "a blank slab of granite." Stuck with nowhere to go, Honnold explains:

There were no cracks or edges to hold on to, just small ripples of texture up a slightly less than vertical wall. I had to trust my life to the friction between my climbing shoes and the smooth granite. … I reached a foothold that I didn't quite trust. Two days ago, I'd have just stepped right up on it, but that would have been with a rope on. Now it felt too small and too slippery. I doubted that my foot would stay on if I weighted it. I considered a foot further to the side, which seemed worse. I switched my feet and tried a foot further out. It seemed even worse. I started to panic. I could hear people laughing on the summit just above me. I wanted to be anywhere but on that slab. My mind was racing in every direction. I knew what I had to do, but I was too afraid to do it. I just had to stand up on my right foot. And so, after what felt like an eternity, I accepted what I had to do and I stood up on the right foot, and it didn't slip, and so I didn't die.

Despite his success, Honnold knew he "had gotten away with something" and he didn't like the feeling. He resolved, "I didn't want to be a lucky climber, I wanted to be a great climber."

Honnold's significant emotional event (SEE) on Half Dome highlights a key takeaway for supply chain leaders. He had paid the price to become familiar with his planned route, but not the price to make it feel safe. Like Honnold, you know the basics of how your processes work. You are familiar with your supply chains. But have you paid the price to gain visibility beyond your direct line of sight, from suppliers' suppliers to customers' customers? Most supply chain managers haven't. They count on business as usual and a little luck to avoid disaster. Consider two instances where supply chain ripples turned into big SEEs.

- **Chrysler gets lucky.** Awed by the vastness of its supply network, Chrysler's purchasing team decided to map its upstream supply chain. This early pilot began with the top-selling, and highly profitable Jeep Grand Cherokee and one of its key components, the V-8 engine, which was produced in a Chrysler facility.

The team opted to trace the origins of a roller-lifter valve supplied by Eaton Corporation. The team visited a small casting shop near the Eaton factory where the valve's raw metal castings were produced. Then they visited the clay supplier where they learned that casting clay has a unique chemical composition. A second, until then undisclosed detail, rattled the team. The supplier had been losing money on sales of casting clay and planned to exit the business to produce more profitable kitty litter. This discovery enabled Chrysler to intervene before the shift into kitty litter shut down its hugely profitable Grand Cherokee line.

- **Blue Buffalo's luck runs out.** A few years ago, pets began suffering kidney failure. The suspected cause: Contaminated wheat gluten. Blue Buffalo, a high-end pet food maker, ran full-page ads hyping the healthfulness of its products, pleading, "You love them like family. So feed

them like family." The ads noted that Blue Buffalo didn't contain wheat gluten.

A few weeks later, Blue Buffalo executives were rattled when they discovered that much of its cat food, which was sourced from C.J. Foods, did contain a contaminated concentrate imported from China. Forced to pull a third of its product line from shelves, Blue Buffalo fell from favor—all because managers lacked deep visibility into the upstream supply chain.

Clearly, it's good to be lucky, but you can't count on luck to get the job done. Honnold learned this on Half Dome. His takeaway: Lucky isn't greatness, nor is it truly satisfying. He chose not to "make a habit of relying on luck" and took the next year off from soloing.

Even so, he began to think of El Capitan. In his mind, it was the "crown jewel of solos … the most striking wall in the world." For seven years, he contemplated, "This is the year that I'm going to solo El Cap." Then he would drive into Yosemite, gaze up at the wall, and think, "No frickin' way." By 2015, he decided he was going to make the attempt. But he was going to do it differently. He would make this ascent feel safe—or he would walk away.

Now, you should be assessing: "Where am I relying on luck, hoping the probabilities work in my favor?" You should also be asking: "Is there anything I don't see, something I might be missing, that could stop my supply chain in its tracks or leave our customers stuck with nowhere to go?" Sadly, SEEs happen all the time. Consider how 2022's computer chip scarcity curtailed auto production or how a shortage of baby formula left mothers high and dry. Similar unforeseen SEEs always lie between you and the summit of success. The good news: Creating the right visibility can help you avoid costly missteps that threaten your competitive survival.

I wanted to do it right

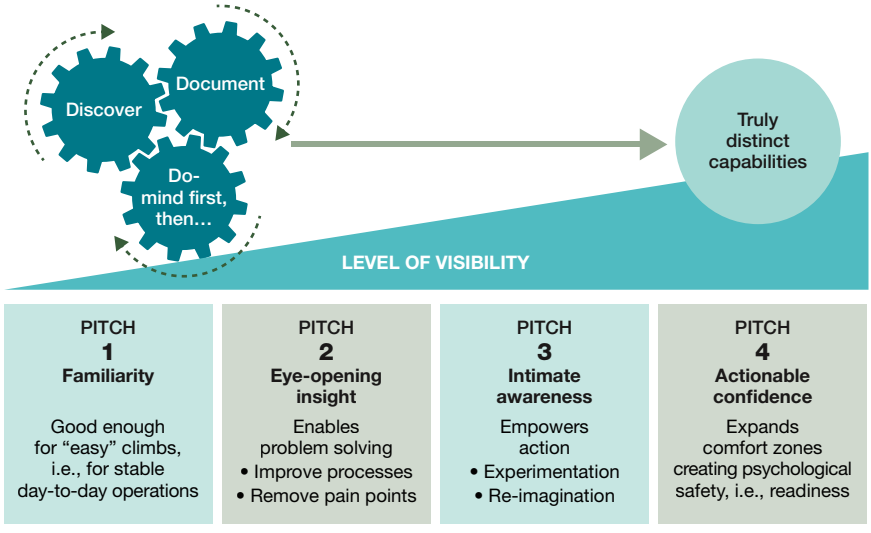
To solo El Capitan the right way, Honnold had to amp up his process. El Capitan was "too big and too scary." Unlike Half Dome, he couldn't just "rise to the moment" and figure it out along the way. His life was on the line. Honnold loved free soloing, but he didn't want to die. As one of the world's best rock climbers, Honnold possessed the technical skills and the physical strength and stamina. But that wasn't enough to solo El Capitan.

With the consequences so high, what did Honnold do to make his ascent feel safe—to do it right? He mapped out his entire route, detailing every dangerous move. He could then re-imagine the moves like a choreographed dance at 2,000 feet. Being able to see the end from the beginning, and every move along the way, was Honnold's key to making his free solo of El Capitan feel safe.

Doing it right would take time and immense effort, both physical and mental, but when "you're either perfect or you're dead," creating a step-by-step map in his climbing journal seemed like a price worth paying. Figure 1 depicts how Honnold, and you, can progress through different levels of visibility to climb to new heights.

FIGURE 1

The levels of visibility maturity



Source: Authors

Let's pause for a process check. What does your El Capitan look like? Based on 30 years of experience working with global supply chain leaders, your quest likely involves leveraging breakthrough collaboration to deliver breathtaking value as you balance competing ESG and risk mitigation priorities. Yours is a daunting climb—one that requires maximum visibility.

That said, few companies pay the price to create maximum visibility. Why not? Managers tell us that the consequences

of missteps don't feel so immediate, so life-threatening. Nevertheless, they are real. A lack of visibility in the supply chain world can lead to the loss of competitiveness and customers, potentially resulting in bankruptcy. Given these very high stakes and today's market volatility, it's time to make visibility a priority.

To see how visibility creates confidence and unleashes capabilities, let's assess Honnold's efforts to create maximum visibility.

Pitch 1: Familiarity

When Honnold left home, he took his mother's van. His goal: Camp where the action was. For a California kid, that meant Yosemite, the center of the rock-climbing universe. By 2008, he had repeated the proven solos in Yosemite, leading him to Half Dome and ultimately to El Capitan. By 2017, he had climbed El Capitan close to 50 times with ropes, including over a dozen ascents of the Freerider route. This *familiarity* taught him that Freerider was ideal for his solo attempt. Freerider combined two critical elements.

- **Difficulty.** Jimmy Chen, "*Free Solo*" director, explains, "Alex chose Freerider … because even as a professional climber, if you are to be able to climb Freerider, what we call clean, which is without falling, that would be a lifetime achievement."
- **Geology.** Freerider follows complex crack systems up the face of El Capitan, perfect for a crack-climbing specialist like Honnold.

Simply put, familiarity gave Honnold the insight needed to pick a doable route. He knew, however, that success would require much more intense visibility investments.

Now, a warning: Honnold's quest began with familiarity. Many companies (our sense is 50% to 60%) seldom go beyond familiarity, a relatively low level of visibility. Familiarity—the basic understanding of how processes work—is good enough for stable day-to-day operations. It doesn't, however, enable breakthrough results or protect against panic when disruptions occur.

Consider this story, shared by a colleague. As a young consultant, he agreed to help a company improve its inventory and order performance. Arriving onsite, he said: "I'm an order, process me." Confused, his new employers asked, "What do you mean?" He led them to where the action was. As he walked them through the order process, he stapled a copy of each related document to his lapel. By tour's end, his lapel was covered in a half-inch set of papers. Rattled by the sheer complexity of the process, managers confessed: "We've never seen the process, end to end, before." Managers tell us the same thing—those at the top can't see the details; those in the trenches get lost in them. No one sees the end from the beginning, and every move along the way.

Now, consider the costs of low-level visibility. Boeing's Dreamliner offers a cautionary tale. In the early 2000s, Boeing and Airbus were engaged in a dogfight for air supremacy. Airbus announced a new plane, the 550-passenger A380. Boeing countered with its ground-breaking, carbon-fiber Dreamliner, later designated the 787. The battle of competing visions turned into a rout. Airlines found the 787's ultra-efficient value proposition irresistible.

Tragically, Boeing didn't deliver on its promise. Design and production snafus delayed delivery to All Nippon Airways, the 787's launch customer, from 2008 to late 2011. Here's what happened: Although the Boeing team had carefully picked supply partners, they had no visibility into supplier operations. Suppliers were extended beyond their capabilities. But Boeing didn't see their struggles until it was too late. Let's tally the costs of Boeing's lack of high-level visibility.

- **Launch costs.** Instead of cutting the 787's estimated $10 billion launch costs in half, relying on suppliers to share costs and take on design escalated costs to over $30 billion.
- **First-mover advantage.** The delays undercut Boeing's first-mover advantage, giving Airbus time to launch the A380.
- **Trust.** Poor supplier integration led to production defects—and two groundings. Most recently, deliveries were halted in late 2020, not resuming until 2022. Rather than wait for Boeing to retool its processes and supply chain, some customers cancelled orders.

Boeing's failure to invest in visibility up front drove 18 years of pain points, hobbling one of its most popular planes ever. Familiarity can get you off the ground, but you need higher-level supply chain visibility to push the limits of achievement.

Pitch 2: Eye-opening insight

To the free soloist, El Capitan is a test of problem-solving ability. Honnold explains: "If there is a single foot of those 3,000 feet I can't climb, then basically I can't do the climb." What does this mean? Honnold needed to meticulously

examine every foot of Freerider. His goal: Identify the critical pain points and figure out if he could safely negotiate them. Of Freerider's 32 pitches, Honnold noted: "There are probably six pitches that worry me the most."

Let's take a closer look at just one, the Boulder Problem on Pitch 26, which Honnold describes as, "a 10-foot section that's incredibly difficult. It's a very intricate sequence." At the end of this sequence, Honnold would need to either "karate kick or double-dyno to an edge on the opposite wall." A few double-dyno attempts convinced him that "jumping without a rope seems completely outrageous, if you miss it, that's that." So, he opted for the karate kick. To make sure he could comfortably make the reach, he did "a nightly stretching routine for a full year."

Scrutinizing the details of how value is created in your end-to-end supply chain is equally important. The good news: Modern visibility toolkits (see "The supply chain visibility toolkit" page 25) can help you discover and document what matters. Consider three opportunities.

1. **Improve internal processes.** To reduce wait times during the peak morning rush, Starbucks sent engineers to observe the action. They noticed baristas needed two scoops of ice to make blended beverages. Their response: Design a "volumetric ice scoop" that could get the job done with one scoop, shaving 14 seconds per drink off prep time.
2. **Remove upstream pain points.** To grow its green strategies, Walmart mapped key product lines to discover how its decisions hurt the environment. To address the risk of foodborne illness, it urged lettuce suppliers to join IBM's Food Trust Blockchain. Greater transparency reduced the time to trace tainted food back to the source from days to minutes.
3. **Leverage customer relationships.** Visibility creates the awareness needed to discover and document touch points that create moments of truth. Zara uses journey maps to capture as-is and ideate to-be service touch points to engage its entire team to turn awareness into loyalty.

Creating the visibility to improve value creation is painstaking, but there are no easy outs. Jim Collins argued that to make the leap from good to great you must confront the brutal facts. You can't confront the brutal facts if you can't see them. Honnold spent two years making El Capitan's brutal facts visible so he could confront and conquer them.

Pitch 3: Intimate awareness

Of course, not all brutal facts are created equal. Eye-opening visibility suffices for many. For instance, during his efforts to make every foot visible, Honnold discovered loose rocks in a 6-foot stretch of crack. So, he and a friend climbed 1,500 feet with an empty backpack to remove the rocks, making his solo attempt safer—both for him and for potential hikers below.

Other brutal facts require intimate awareness, a mix of deep insight and ingenuity. Freeblast exemplifies one of these. Why the need for elevated visibility? Short answer: Freeblast unnerved Honnold, a psychological fact he had to confront. After all, Freeblast is a blank slab, like the one on Half Dome that had induced panic in 2008. Further, during a 2016 rope-assisted climb, he had fallen on Freeblast, badly injuring his ankle. Then, on his original free solo attempt, in November 2016, a foothold on Freeblast didn't feel right. So, he bailed. Honnold confessed, "For years, Freeblast has given me the heebie-jeebies."

Given his inner turmoil, how did Honnold make Freeblast feel safe? He returned to the insecure foothold, where he admitted, "I don't really wanna have my whole life depend on standing on this one right foot." So, he scoured Freeblast's 150 feet of slick granite—toothbrush in hand to clean away the grit—looking for another way. He came up with his own variation, i.e., a detour, around the slippery foothold. These variations are one of Honnold's secrets. He frames it this way: "I love the movement of climbing … It's like an enormous puzzle." One variation involved 20 easier moves to get around a foothold he wanted to avoid. For each moment of angst on Freerider, Honnold "worked it down to the point it felt solid."

Honnold's variations are your process innovations. Honnold worked out each variation safely tethered to a rope. Your visibility toolkit lets you safely test "What if?" options. Bosch's Reutlingen semiconductor facility, for instance, built a digital supply chain twin—i.e., an AI-enabled simulation—so it could re-imagine its supply chain, testing process innovations, big and small. The goal: Safely and quickly adapt to a dynamic market. Only the best solutions in the digital world are tested in the real world. If the pilot works, the idea is implemented. Digital twins mirror your world, letting you experiment at a low cost and an acceptable risk. Just remember, you need intimate awareness to build a valid digital twin. Otherwise, GIGO applies.

Pitch 4: Actionable confidence

By spring 2017, Honnold had mapped the entire Freerider route, committing it to memory. Hearing this, people query, "You memorized 3,000 feet of climbing?" His response: "I didn't have to memorize 3,000 feet of climbing, but I memorized the hundreds of feet that mattered, you know, all the hardest climbing was fully memorized."

Look at Honnold's climbing journal and you'll see how he matched detail to difficulty. For a routine pitch, he kept it simple: "Eight, easy romp. Go fast." But for the crux—i.e., the hardest part of the climb—he choreographed every move:

Pitch 26, sort of lie back and up the corner, key left-hand pinch thing, right foot back step on the lower edge, left foot faced against the wall, stand up. … Right foot sinks low to a flat edge, left foot steps through to an edge, right foot back steps really high so you can sag your weight under the corner without having to swing. … Left hand to the other under cling. Switch your feet on the rail and then reach through the jugs, and then it's done.The key thing for the crux, pull hard, trust feet, trust!!. Autopilot.

These detailed notes were a critical input to Honnold's goal: Actionable confidence. They enabled him to visualize his solo. He describes it this way:

So, I'm imagining the moves, … And not just the movement and getting it right. But also, what it will feel like, the grains of the rock in my fingers and the exposure and like, you know, the sensation of the air around me. I'm trying to visualize every component of the experience so that nothing would catch me by surprise while I was up there.

Before he soloed El Capitan physically, Honnold had already done it 100 times in his mind. He had cultivated the confidence that free soloing El Capitan was doable. He was ready.

When Microsoft set out to take its Xbox supply chain to the next level, project leaders built a state-of-the-art control tower. Their goal wasn't just to provide supplier-to-customer visibility. They wanted to unleash big data and machine learning to enhance decision-making. But they knew engineers would hesitate to give up control. They needed to cultivate trust in the system—and the process. How did they do it?

- They spent an entire year to get visibility right, asking: What do we care about? What data do we need? Can we get it?
- With dashboards designed, they turned to proving the analytics. When deviations occurred, proactive alerts were sent, saying, "I found an anomaly, maybe you should look at this." As the system learned, it added, "Yesterday you did this, maybe you should do the same."

Evidence accumulated. Confidence grew. Everyone was ready to make the "go" decision. Machines took over the routine issues, freeing up time for engineers to take on big things.

Visibility: It's a matter of trust

"On the day of the climb, it felt as natural and comfortable as a walk in the park," Honnold recalled, "which was what most people were doing in Yosemite that day."

El Capitan was everything Half Dome wasn't: Satisfying mastery. Honnold trusted his process. He trusted himself. Everything felt automatic. That is the power of actionable confidence.

Regrettably, visibility-enabled supply chain mastery is rare, just like solos of El Capitan. Why? Most companies settle for familiarity. Only one in three pushes for eye-opening insight; one in 10 for intimate awareness. The result: Supply chains built for a roped Half Dome climb struggle under the stress of soloing El Capitan-like challenges. Lacking vital visibility, it's no surprise many headlines herald supply chain failures.

Consider 2022's baby formula crisis. After six months of pain, the press exclaimed: "The shortage persists because of panic buying. Consumers have lost trust in the supply chain." How did we get to this point?

- **Minimize investment**. Relying on familiarity, the lowest level of visibility, the U.S. Food and Drug Administration closed Abbott's Sturgis, Mich., facility in February. By April, inventory fell 40% coast-to-coast. Stockouts climbed, so did mothers' stress.
- **Escalate, but …** To alleviate the stress, the Biden Administration upped its game to eye-opening insight and began airfreighting formula from overseas. By July, it had imported 61 million bottles total—about one week's usage. Yet out-of-stocks remained high at about 30%.

You may recognize this minimize-then-escalate pattern. Why is it so common? Because visibility requires enduring effort, managers, focused on the here and now, settle for familiarity, which is often good enough. Sometimes they escalate to eye-opening insight, but they seldom go beyond.

Don't settle. Distinctiveness, and the opportunity for real mastery, reside in higher-level visibility. Here's how you can follow Honnold's lead and make your case for high-level visibility before crises hit.

The supply chain visibility toolkit

As Honnold approached the base of El Capitan on June 3, 2017, all he took with him were his favorite chalk bag and a pair of $250 La Sportiva TC Pro shoes. In a way, his simple toolkit exemplifies yours. The chalk represents your classic low-tech visibility tools. The shoes, your state-of-the-art, high-tech visibility tools. The sticky rubber sole of modern climbing shoes revolutionized soloing. Without these high-tech shoes, friction climbing would be impossible.

Let's briefly review some of the tools you can use to create the visibility needed to design and manage a world-class supply chain.

Your visibility toolkit

	SC VISIBILITY TOOL	EXEMPLAR	DESCRIPTION
Low-tech tools	Observation	Starbucks	Engineers visited stores to seek opportunities to improve processes, efficiencies, and service. In 5 years, these efforts increased store revenues by almost 25%.
	Mapping, e.g., process/ value stream	Pfizer	Pfizer's Lipitor team employed value-stream mapping to make end-to-end processes visible. Some activities were eliminated, others streamlined, reducing lead time by 60%.
	Cadence call, e.g., integrated business planning	Best Buy	Facing disruptive competitive pressure, Best Buy relied on cadence calls to reduce costs and enable price matching. The ability to match Amazon's prices revived growth, profitability and Best Buy's stock price.
	Pilot projects	Procter & Gamble	P&G and Paboco, a packaging supplier, ran a test-and-learn pilot to identify how to scale the use of paper packaging to meet P&G's EU sustainability goals.
	RFID	Audi	Audi deployed RFID tracking in their Hungarian operations to track each car's status and location, reducing labor costs and improving shipping accuracy.
	Computer vision	Vancouver Fraser Port Authority	The port authority uses computer vision to track container movement, expedite inspection, and identify opportunities to improve ground operations.
	Supply chain control tower	DHL	DHL developed a Global Control Tower to improve the visibility of shipments and reduce standard and expedited transport spend. The control tower increases customer confidence in DHL's service capabilities.
High-tech tools	Blockchain	Walmart	Walmart launched a blockchain initiative to track and trace leafy greens from farm to market in real time. The goal: Increase food security by responding to food contamination crises quickly and efficiently.

Source: Authors

1. **Emphasize possibilities.** Without the allure of soloing El Capitan, Honnold wouldn't have achieved actionable confidence. Are changing the competitive rules or mastering risk/sustainability big enough ideas to motivate your team to seek greater visibility? Don't forget, the bigger your quest, the more visibility you need. Actionable confidence makes it feel safe to expand your own and your team's comfort zones.
2. **Focus on process.** People often wonder, "How does Honnold do the hard free solos?" His answer: "I've never been gifted." He stresses, "The majority of the time you spend sport climbing, you're failing. … Climbing reminds you that to get better at anything, you've got to put in a tremendous amount of time and effort." Success is found at the end of a meticulous process. Trust the process—it will work for your supply chain.

One final thought: Perhaps you've Googled "supply chain visibility." The top returns all focus on technology. These high-tech tools can enhance supply chain visibility. But you can get much of visibility's benefit without making big-money outlays. The simple tools work.

The opposite, however, isn't true. We have yet to find a company that leveraged the high-tech tools that didn't first follow a meticulous visibility process. That said, it's time to take your company to new heights. The visibility climb is steep, but you will love the vistas—and the returns—you find at the top of your El Capitan.

SUPPLY CHAIN RISK MANAGEMENT PLANNING

Risk management doesn't have to be complex. This practical, easy-to-implement framework supports decision-making and risk management.

BY TAN MILLER

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Editor's note: *Portions of this article were excerpted from* "Supply Chain Planning: Practical Frameworks for Superior Performance, Second Edition" *by Tan Miller and Matthew J. Liberatore, and published by Business Expert Press.*

In early 2020, the tragic onset of a global pandemic dramatically raised the visibility of supply chain risk management (SCRM). The sudden disruptions to everyday life, businesses and supply chains worldwide brought on by the coronavirus forced an almost instantaneous rethinking of supply chain operations, management and risk across all industries.

In this article, recognizing the heightened importance of risk management, we illustrate practical, easy-to-implement SCRM frameworks and analyses to support supply chain decision-making and management. We begin with a short review of the types of risk that firms must assess in creating their risk management strategy. This review provides context for the frameworks that we will introduce. After this brief review, we then turn to the focus of the article and present several illustrative SCRM frameworks and analysis templates.

Risks to consider

When constructing a supply chain risk management strategy, a firm can assure that it undertakes a holistic view of all potential threats by first evaluating general categories of risk, and then considering specific individual risks. Why take this two-step approach? The danger of immediately focusing on a few specific known risks to a firm before first performing a broad review across all risk types is that immediately diving into specifics may cause some less obvious, but important risks to be overlooked. Hence the need for a two-step approach. Figure 1 presents nine broad categories of generic risks (column 1), and offers examples of each category of risk (column 2).

FIGURE 1

Summary of risk types, sources and strategies

Type of risk	Sources	Illustrative alternative strategies
Supply risks	Disruption of supply, inventory, schedules, and technology access; price escalation; quality issues; technology uncertainty; product complexity; frequency of material design changes	Multiple sourcing, operational flexibility, risk sharing
Operational risks	Breakdown of operations; inadequate manufacturing or processing capability; high levels of process variations; changes in technology; changes in operating exposure	Maintain duplicative or excess capacity, high levels of maintenance
Demand risks	New product introductions; variations in demand (fads, seasonality, and new product introductions by competitors); chaos in the system (the bullwhip effect on demand distortion and amplification)	Postponement, risk sharing with customers, high levels of safety stock
Security risks	Information systems security; infrastructure security; freight breaches from terrorism, vandalism, crime, and sabotage	High investment levels in security technology, minimize sourcing and firm-owned infrastructure in less stable geopolitical environments, high levels of physical security investment
Macro risks	Economic shifts in wage rates, interest rates, exchange rates, and prices	Currency hedging initiatives, diversification of product lines
Policy risks	Actions of national governments such as quota restrictions or sanctions, as well as actions of regional and local government entities	Avoid significant investments in perceived unfriendly international markets, invest heavily in lobbying practices
Competitive risks	Lack of history about competitor activities and moves	Defensive product line and entire company mergers and acquisitions, acquisition of key competitive personnel, first to market approaches
Resource risks	Unanticipated resource requirements	Conservative balance sheet approach including high cash balances
Natural risks*	Tornadoes, tsunamis, hurricanes, fires, pandemics	Avoid facility location in geographies subject to frequent earthquakes, tornadoes, and hurricanes

*Natural risks have been added to the original eight types of risks noted in Manuj and Mentzer (2008).

Source: Manuj and Mentzer (2008)

Note that these risks range from those over which a firm has direct control (e.g., the operational risk of "inadequate manufacturing" capacity or capability), to risks such as tornadoes and hurricanes (natural risks) which a firm cannot control. Because we cannot extensively explore risk types, sources and SCRM strategies in this short article, we provide additional references at its end for readers interested in pursuing these topics in depth. However, a careful reading of Figure 1 offers sufficient background for our purposes here.

We close this introduction of supply chain risk by reviewing column 3 of Figure 1. This column displays common strategies often employed to mitigate the threat of each risk type. For example, a heavily utilized supply risk strategy consists of employing multiple sources to procure individual products or materials. While using more sources rather than fewer sources generally reduces the opportunity to minimize acquisition costs, it also lessens a firm's dependence on any single supplier.

The need to understand this type of risk mitigation trade-off (i.e., cost versus level of vulnerability) leads to the primary question this article addresses: *What are practical frameworks and analyses a firm can utilize to assess the level of risk it faces on its supply chain?* A firm that accurately evaluates its risks through well-structured and regularly updated SCRM frameworks, positions itself to make sound, well-informed decisions as to the level of risk mitigation efforts and investments it should undertake.

In the following section we offer several examples of how firms can evaluate risk from the perspective of a hierarchical SCRM framework. We assume that the example firm has completed the process of identifying all possible generic risk types it may face, and now is assessing several very specific risks. We focus on supply risks and demand risks for illustrative purposes, two of the risk types described in Figure 1.

Disaggregate and prioritize individual risks

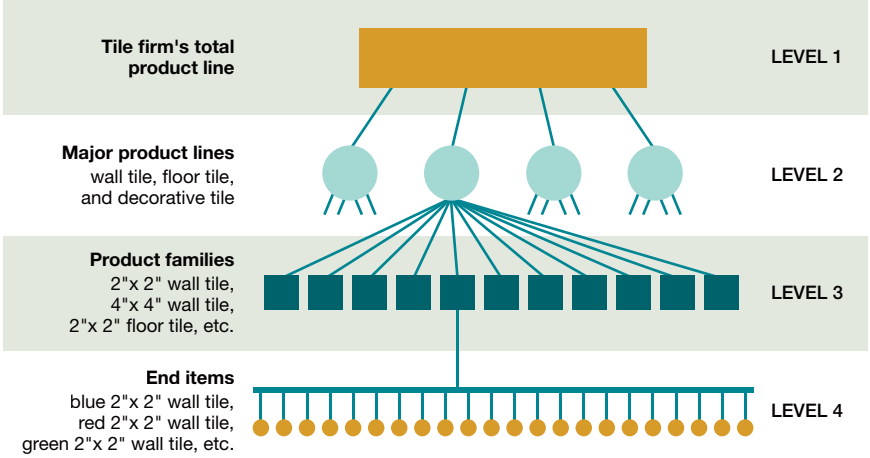
When evaluating a particular risk (e.g., the uncertainty of demand), disaggregating the components of the risk—in other words, viewing it hierarchically—provides guidance to better understand and address the risk.

Demand risk. For illustration, let us consider a fictitious, multinational ceramic tile manufacturer headquartered in the United States, seeking to understand its vulnerability to volatility in demand for its products, and to craft a strategy to protect itself against the volatility. Figure 2 displays the product line hierarchy assumed for this example.

The firm can utilize this product hierarchy to prioritize and organize its risk management approach and strategy.

FIGURE 2

Firm's product line



Source: Authors

Figure 3 displays an illustrative template a tile manufacturer can employ to analyze demand risk factors at the highest sublevel of demand, namely, the product line level. Note that the first column of the figure contains assorted measures that offer perspective on the relative importance of the product line, its domestic versus international mix, the number of major competitive products each product line faces, the firm's historical ability to forecast demand accurately and the marketing department's perceived level of control to influence demand.

At the bottom of the first column, note that the template has three rows of descriptors where across each row decisions can be displayed depending on the measures analyzed above. Briefly, these decisions include the relative priority of the product line to the firm, a decision whether a common or separate risk mitigation strategy should be used for each

FIGURE 3

Product line demand analysis

Measures		Product line: Wall tile	Floor tile	Decorative tile
Percentage of global sales				
Percentage of U.S. sales				
Sales ($000)				
Unit sales (000)				
U.S. vs. international percentage of sales	U.S.			
	International			
Number of major competitive products				
Marketing's ability to influence/control demand*				
Historical forecast accuracy percentage				
Decisions				
Priority†				
Common** or separate strategy				
Responsible person††				

* Based on a scale of 1 (very low) to 5 (very high)
† Priority of product line
** Same or separate strategy for all product lines
†† Who in firm is responsible for this?

Source: Authors

product line, and who is responsible for the risk mitigation strategy for a product line. Figure 3 provides examples of analytic measures and decisions; however, the appropriate components for this template must be customized on the basis of an individual firm's operating environment. Whatever the appropriate composition of measures and decisions utilized by a firm, the important point is that a firm must employ a rigorous analytic framework, as illustrated in Figure 3.

After completing its analysis at the product line level, the tile manufacturer would next perform a similar analysis at the product family level (i.e., at the next lowest level of product disaggregation). Figure 4 presents a template similar to the one previously shown in Figure 3. At the product family level, many firms, including tile manufacturers, may have tens

FIGURE 4

Product family demand analysis

Measures		Product families: Wall tile 2x2	4x4	6x6	8x8	12x12	Floor tile 2x2	4x4	6x6	8x8	12x12	Decorative tile 2x2	4x4	6x6	8x8	12x12
Family's percentage of product line's sales																
Percentage of global sales																
Percentage of U.S. sales																
Sales ($000)																
Unit sales (000)																
U.S. vs. international percentage of sales	U.S.															
	International															
Number of major competitive products																
Historical forecast accuracy percentage																
Decisions																
Priority*																
Common† or separate strategy																
Responsible person**																

* Priority of product family
† Same or separate strategy for all product families in the product line
** Who in firm is responsible for this?

Source: Authors

to hundreds of individual families. Thus, it becomes very important at this level for a firm to determine the optimal level of its analytic efforts. For example, below some threshold of sales dollars or percentage of total company sales, the benefits of a significant analytic evaluation of a product family may be negligible. Thus, at the product family level, only selective analytic work may be required.

Finally, analyses conducted and decisions made at the product line and product family levels can be extended to the end item level if necessary. For many firms, this is not necessary; however, some firms may have one or several end items that represent a major portion of total sales, or hold strategic importance for the firm. In such cases, selective analyses and individual end item strategies may be required. For example, a manufacturer may produce one or more end items exclusively for a key customer such as Walmart. Consequently, the end item may have greater long-run strategic importance to the manufacturer than just its current sales contribution (i.e., the end item may hold special intrinsic value to the relationship with the customer). Thus, a risk mitigation strategy such as maintaining higher inventory levels than normal or some other strategy for the particular end item may be warranted.

Supply risk. Figure 5 displays a typical production and supply network for a large-scale manufacturer. There exist, of course, numerous variations on this structure such as in the auto industry that often utilizes multi-echelon, company-owned manufacturing plants (e.g., a network of component plants supplying final assembly plants).

However, regardless of a firm's manufacturing infrastructure, typically it will have several tiers (i.e., echelons) of suppliers. As depicted in Figure 5, suppliers who ship materials and components directly to a plant represent the "Tier 1" suppliers, while Tier 2 and Tier 3 suppliers fulfill material and component requirements of Tier 1 and Tier 2 suppliers, respectively. This hierarchy of plants and suppliers offers a logical framework for decomposing a firm's supply risk analysis.

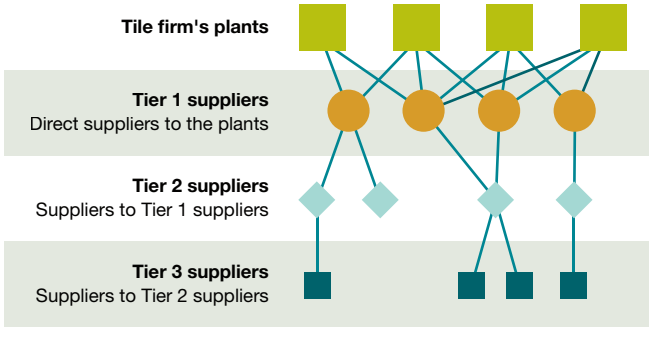
As Figure 6 illustrates, beginning with its own plants, a manufacturer must evaluate numerous variables to assess the relative risks to its operations that each plant faces. Based on its analysis, the firm develops measures that facilitate this evaluation. Then, as shown at the bottom of the first column in Figure 6, the firm establishes the priority or ranking of each plant's risk level; whether a plant requires a unique risk mitigation strategy or whether a common strategy across several plants will suffice; and, finally, who is the person responsible for overseeing all risk mitigation-related efforts at a plant.

The manufacturer completes this process for each of its plants, and then performs similar analyses beginning with its Tier 1 suppliers, and ultimately all pertinent echelons of suppliers (e.g., Tier 2 and Tier 3 suppliers).

Clearly, for a firm with hundreds or thousands of suppliers, a judicious selection of which suppliers require a thorough evaluation must occur. It is entirely possible that in some cases, a Tier 2 supplier may require more

FIGURE 5

Firm's manufacturing and supplier network



Source: Authors

FIGURE 6

Manufacturing plants' analysis

Measures		Plants			
		Plant A	Plant B	Plant C	Plant D
Percentage of global sales					
Percentage of U.S. sales					
Sales ($000)					
Unit sales (000)					
U.S. vs. international percentage of sales	U.S.				
	International				
Potential capacity (units)*					
Potential capacity (sales $)*					
Current utilization rate (%)					
Number of direct suppliers					
Number of direct single-source suppliers					
Number of suppliers from local country					
Number of foreign suppliers					
Geopolitical risk level in local country†					
Quality, stability of suppliers**					
Decisions					
Priority††					
Common*** or separate strategy					
Responsible person†††					

* Based on optimal utilization rate (e.g., 85%)
† Based on scale of 1 (low) to 5 (high)
** Based on scale of 1 (low) to 5 (high)
†† Priority of plant
*** Same or separate strategy for all plants
††† Who in firm is responsible for this?

Source: Authors

scrutiny (and may pose a greater risk) than a Tier 1 supplier. Alternatively, some firms may find they have few, if any, Tier 2 or, particularly, Tier 3 suppliers, who warrant a comprehensive review. In general, it is simply not feasible or economically prudent to rigorously evaluate all direct and indirect suppliers. A high-level hierarchical analysis, as illustrated in this section, provides the foundation to determine the level of analytic effort a firm should expend on its individual suppliers and plants. The appropriate and most insightful measures often vary by firm, industry, and country. However, the basic analytic approach outlined here offers general guidance that all firms can employ in their SCRM evaluation, and, ultimately, their strategy development process.

Figure 7 displays a sample of the typical measures that a manufacturer would develop to ascertain the risk level associated with each of its Tier 1 suppliers. Again, the appropriate measures and the analyses required to derive these measures will differ by firm, industry, and country. However, Figure 7 illustrates the types of business insights that a firm must generate

FIGURE 7

Tier 1 suppliers' analysis

	Tier 1 suppliers			
Measures	**Supplier A**	**Supplier B**	**Supplier C**	**Supplier Z**
Percentage of global plant purchase ($) provided by				
Percentage of purchase ($) by local country plant(s) provided by				
Number of other suppliers who provide same products (materials) as				
Perceived ability to add new suppliers rapidly for products supplied by supplier*				
Geopolitical risk level in local country†				
Quality, stability of suppliers**				
Decisions				
Priority††				
Common*** or separate strategy				
Responsible person†††				

* Use scale of 1 to 5, with 1 being easy, 5 being very difficult and/or requires long lead time
† Based on scale of 1 (low) to 5 (high)
** Based on scale of 1 (low) to 5 (high)
†† Priority of supplier
*** Same or separate strategy for all suppliers
††† Who in firm is responsible for this?

Source: Authors

to formulate a strong risk assessment and prioritization approach to its supply risk.

Additional analyses would next be developed at the Tier 2 and Tier 3 levels. As similarly noted in the previous demand risk example, an important part of the supply risk process consists of the manufacturer determining the optimal breadth and depth to which it should undertake this analysis. The Tier 2 and Tier 3 levels may have hundreds or even thousands of very small indirect suppliers. Clearly, therefore, a firm must judiciously allocate the amount of resources and time expended in evaluating many of its indirect, and in some cases, direct suppliers. At the same time, a manufacturer must be alert for any potential critical single or scarce resource suppliers hidden in their lengthy lists of indirect and direct suppliers.

Finally, with respect to supply risk, it is important to recognize that this represents an area where a manufacturer can help themselves immensely by building good relationships with their key suppliers. If a firm develops a strong relationship with a Tier 1 supplier based on trust, shared goals and mutual benefits, then the firm can comfortably delegate to this key Tier 1 supplier a significant portion of the supply risk analysis of that supplier's own direct and indirect suppliers (i.e., the Tier 2 and 3 suppliers of the manufacturer). Thus, cultivating strong relationships with its direct suppliers allows a manufacturer to lower its own level of effort required to evaluate Tier 2 and Tier 3 suppliers.

For example, assume that a manufacturer chooses to collaborate with a key Tier 1 supplier on its internal product and production design processes. This will facilitate a better understanding by the Tier 1 supplier of how their components meld into the finished goods manufacturing process. Besides the potential manufacturing efficiency benefits that a collaborative process may generate, this approach will also strengthen the manufacturer's knowledge of, and trust in their Tier 1 supplier, and vice versa. Hence, the manufacturer may more confidentially entrust the risk review of some Tier 2 and Tier 3 suppliers to their Tier 1 supplier.

Hierarchical policy risk. In the previous section, we utilized demand risk and supply risk to illustrate a hierarchical approach for dissecting the components of a specific potential threat. The other high-level types of risks described in Figure 1 can similarly be disaggregated to facilitate a thorough evaluation and understanding of a risk type. As one brief final example of this approach, we consider government policy or regulatory risk. Figure 8 presents a hierarchical perspective on the governmental and quasi-governmental entities that create and administer laws, policies and regulatory requirements which govern a firm's operations.

Clearly there are tens of thousands of domestic and international governmental municipalities and regulatory bodies, and a firm will frequently need to consider only a small subset of these entities. However, employing the hierarchical perspective conveyed by Figure 8 will enhance the success of a firm in identifying those laws, regulatory bodies, and governments that require particularly close attention. For example, in the United States, a firm may determine that addressing a particular regulatory concern at the federal level may obviate the need to do so at the state and local levels, or vice versa.

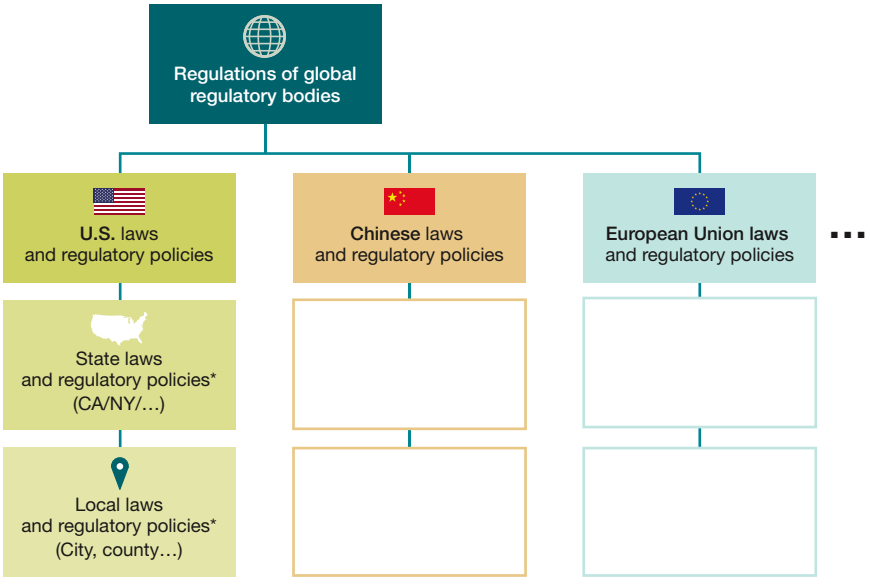
Standardize methodologies

It is important to create standard SCRM business methodologies that can be repeated regularly. In short, a firm should establish a standard decision support infrastructure that it regularly updates and enhances. The types of frameworks and analyses illustrated in this article to support SCRM efforts represent decision support tools that a firm should develop and maintain as a regular business process. Investing in these SCRM frameworks and analyses will greatly enhance a firm's ability to assure resilience and continuity in its operations, at all levels of the supply chain.

This article has focused on techniques that firms can enlist to identify, evaluate and prioritize supply chain risks. The actual development and implementation of strategies to mitigate or insulate a firm against a potential risk follows after the evaluation process, and is beyond the scope of this article. However, the reader interested in a comprehensive review of real-world case studies and guidance on strategy development and implementation is referred to the references listed below. For a more detailed discussion on supply chain risk identification processes, types, sources and analytical frameworks presented in this article, the reader is referred to "*Supply Chain Planning: Practical Frameworks for Superior Performance, Second Edition,*" which served as the basis for this article.

FIGURE 8

Hierarchy of entities that create regulatory policies and laws



* The level of detail that requires evaluation will vary by firm and country. Clearly there are tens of thousands of governmental municipalities and regulatory bodies that a large multi-national firm may come under the jurisdiction of.

Source: Authors

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5 WAYS AI IS CHANGING SUPPLY CHAINS

Used in everything from delivery to forecasting, artificial intelligence is leaving its mark.

BY GARY FORGER, DIGITAL EDITOR

Artificial intelligence (AI) is already making its way into the supply chain. If you missed the launch, then it's time to track the trajectory of AI's impact from managing initial demand to final-mile delivery.

So, where does AI fit in today's supply chain?

Only six short years ago, the trade association MHI published a supply chain roadmap looking out to 2030. In that, AI and several other emerging technologies were discussed. They were also treated as if they were silos. Even curiosities. And to say the least, all were considered a long way from migrating into real-life supply chain applications.

Well, the world moves at a much faster pace. AI has already worked its way into several aspects of the supply chain. Each of the stories that follow are examples of that. Interestingly enough, at least a couple of them were live

before that supply chain roadmap was written.

Applications here include last-mile and on-demand delivery, on-demand manufacturing, demand forecasting and document processing. That's a fairly wide dispersion of applications. What they all have in common is that AI makes them better than what humans can do. In some cases, humans don't stand a chance at doing—at any pace or degree of accuracy—what AI can do. The more complex the task, the better the AI fit. It is all about taking mammoth mounds of data, finding patterns that matter, and translating that information into actionable to-dos that improve, in these cases, the supply chain.

Editor's note: *This article was written by a real person. There was no temptation to turn it over to ChatGPT or any other commercial algo out there, in case you were wondering.*

This is a good time to remind ourselves that AI, for all of its grand accomplishments and outrageous hype, is still an emerging technology that is finding its place. The following five stories will give you some insight into the trajectory of AI in the supply chain. Each speaks for itself.

On the road to the optimized route

AI makes on-demand delivery manageable.

In on-demand delivery, there's not a lot of room for error, especially when the deliverables are food and pharmaceuticals. But we aren't talking only one or a few deliveries here.

Senpex has scaled its on-demand delivery service to 10 states and 8,000 drivers since its founding in 2017. And from the beginning, artificial intelligence has been an essential component in optimizing routes that enable deliveries in one hour or less, says Anar Mammadov, CEO and founder. "We built our AI engine to solve that problem in real-time so we can meet delivery times as short as 30 minutes," he adds.

Quite simply, there's a lot of complexity here. There are the items, their pickup and drop-off locations, driver availability and reliability, delivery times and route optimization just to start. "AI is the centerpiece of our multi-route optimization engine to coordinate all of the factors and make deliveries on time," says Mammadov.

And Senpex has done fairly well here based on the company's own statistics. The company says it has 98% customer satisfaction across its 65 marketplaces.

There are two forces at work here. One is the real-time, on-demand delivery. The other is the scalability of the business that Mammadov wants to build.

To the former, he says AI and machine learning provide automation of the data from several points. These include the specifics of the order alongside the specifics of each driver's historical performance as well as the availability and original position of the driver relative to the order. There's also the routing of both driver and deliverable from point A to point B, including any rerouting made necessary by traffic jams and other delays along the way.

Ultimately, it's an against-the-clock supply chain optimization challenge in a very compressed time frame. Mammadov says AI is essential to compensate and reroute in real time for any and all unforeseen circumstances that could delay that delivery. He calls it the optimized route. And as you already surmised, drivers access it on an app.

There's also the matter of the drivers themselves. Mammadov is zoned in on having reliable, dedicated drivers. AI ranks the drivers against a list of criteria ranging from on-time performance to consistency over time. This has resulted in the creation of an AI-based data analytics dashboard for each driver.

That data is an integral part of driver selection for each individual delivery, says Mammadov. In fact, it has led to the creation of something called Senpex Flex. This service allows corporate clients to book dedicated delivery drivers for their consistent delivery needs. Mammadov claims neither Uber nor DoorDash have been able to solve the problem of dedicated drivers.

As to the scalability of the business, that's where Mammadov uses a longer horizon for AI. "We can grow the business to any size easily as long as we have the AI to manage the increased complexity of more drivers across more marketplaces. Without AI, our future will be limited."

AI in aisle 7

How grocers and other retailers can get some help with on demand forecasts.

There is probably no supply chain that could use more help these days than retail. And from Troy Prothero's perspective, demand forecasting is a great place to start to improve the retail supply chain with artificial intelligence.

As senior vice president of product management, supply chain solutions at SymphonyAI Retail CPG, Prothero has seen time and again how the technology is "a finely tuned instrument" for managing forecast accuracy, store service levels, inventory levels and more.

Quite simply, he says, AI manages a much broader range of data than standard statistical analysis. It goes beyond historic sales and includes promotional and other contextual data. These range from the items themselves to weather events, calendar events (Super Bowl), social media data and promotional patterns by item and time of year, to name only a few.

"What we're looking at here is not just what sold in the past but also why and under what conditions those sales took place," says Prothero. "And from that we use AI to extrapolate [demand for] future sales," he adds.

He tells the story of a Tier 1 grocer with thousands of stores. The platform cleansed, filtered and clustered historical and contextual data as well as item and location attributes. Using AI, it automated the item forecast by day and location for both dry and fresh goods in 13-, 26- and 52-week increments. Weekly reviews were made to compare forecast to actual.

"There was a measurable impact," says Prothero. "Forecast accuracy increased by 10 points and service levels to stores rose by 1.5 points. In addition, manual intervention to forecasts and orders by DC was reduced by 60%," says Prothero.

The benefits didn't stop there. Service levels increased without increasing inventory levels. In fact, inventory holding costs fell. Demand planning efficiency increased sufficiently that the number of stores serviced could be increased without adding staff. Meanwhile, waste and shrinkage fell.

"We know we can produce a great forecast with AI," says Prothero. "But the harder part is getting people to trust the forecast."

He points out that standard, statistical forecasts rely on domain experts and their involvement to build them. However, AI is, in his words, a black box and people don't know how the forecast is created.

Trust has to be built because users come with great skepticism, says Prothero. And that even includes the data scientists on staff. "The data scientists trust AI but are more opinionated than others when learning to trust the forecast," he adds.

Collaboration on the forecast goes a long way to building trust. For instance, there may be a concern if a promotional event's data was properly represented in the data presented to the AI platform. That, says Prothero, requires users to review and assess the data to the point of changing the AI forecast itself.

"The final step is to track performance and identify shifts in the forecast based on changes in the data. It's all a matter of giving people a chance to prove to themselves that the AI is accommodating all of the data and coming up with the right forecast," says Prothero.

"Getting people to trust the forecast is the final hurdle AI has to clear to have a future in the retail supply chain," he adds.

Removing friction from the supply chain

Automated document processing speeds workflow considerably.

"It's all about removing friction in communication between business partners and across the supply chain." That's Petr Baudis' summary of the value of Rossum's AI and machine learning-based document processing system.

The founder goes on to say that AI speeds the workflow of purchase orders, packing lists, invoices and other key procurement documents. "No individual should ever have to see the documents once they have been issued. An AI-based platform fully automates the routing, processing and final disposition of the documents," says Baudis.

The idea started with Baudis and two other AI Ph.D. students, Tomas Gogar and Tomas Tunys, in Prague in 2017. In fact, the idea of managing documents with AI was so compelling the trio dropped out of their academic program to start the business. For what it's worth, the name Rossum was picked for its connection to Czech writer Karel Capek's play "Rossum's Universal Robots."

Actually, there is nothing that could be any more robotic and timesaving than the handling of documents in the cloud using AI's data-extraction capabilities. "We are actually condensing the supply chain by removing friction and gaps between stages in the handling of procurement and related documents," says Baudis.

In an interview with Forbes, Gogar said that Rossum's first proof of concept was almost too successful. After the first run, the people at Siemens suspected that Rossum had cheated and manually processed invoice documents. So, Siemens asked for a second run with an increase in

document volumes. The result was the same, described by Gogar as an order of magnitude better than how Siemens had previously processed the documents. Users of the AI-based system now include Molson Coors, Morton Salt and Siemens among many others.

Baudis says average document processing time savings across companies of all sizes is 82%. And the AI-based platform automates 98% of actions required to process documents compared to only 50% with conventional optical character recognition.

The Rossum approach breaks down into four distinct activities: pre-processing, data capture, validation, and post-processing.

Pre-processing is all about customizing the data fields desired. Data capture occurs when purchase orders and other documents are uploaded to the Rossum AI platform by e-mail, PDF or scanned images to a user interface. Validation of data uploaded in less than a minute regardless of volume is through the user interface. Post-processing occurs when the data captured is exported to an ERP or accounting system for both internal use and communication with business partners.

The magic happens here when AI automatically extracts data, says Baudis. But the AI also makes it learn on the job and get better at collecting and managing the data over time. "There's no need to configure the AI. It learns on its own," Baudis adds.

And just as Siemens had some doubts about AI, Baudis says that is entirely natural and expected. "It can take months to years for companies to completely trust in the AI. It all comes down to a company's degree of electronic integration, its complexities and acceptance of risk," he adds. But from talking to Baudis, no company's lack of trust has ever gotten in the way of AI doing its job. Fortunately.

How to limit emissions for deliveries

Evaluation of vehicles, loads, routes and other factors is critical.

"Deliveries and logistics are moving closer to CEO-level conversations," says Shailu Satish, co-founder and COO of last-mile delivery software company DispatchTrack. That's not so surprising as deliveries and logistics are details of the supply chain, which most everyone agrees is moving up the corporate power chain.

But then Satish says something unexpected. "CEOs are now thinking about emissions from their deliveries and logistics routes." Emissions?

But she has the data to back it up. In a survey of nearly 150 logistics professionals in November 2022, DispatchTrack found that eight of 10 companies have sustainability initiatives in place. But when Satish drilled down, she found that 54% of companies have a strategy to improve their own fleet's routing efficiencies to limit emissions. And 16% already offer delivery options that limit emissions.

There is an important distinction here between DispatchTrack and Senpex. The former offers an AI-powered SaaS platform that provides real-time visibility into delivery orders from dispatch to destination. Its corporate clients include Coke, Walmart and J.B. Hunt and manage their own delivery fleets. Senpex uses AI to manage the routing and driver selection of the delivery fleet that it manages for others.

As a last-mile delivery software company, DispatchTrack has been using AI to power its software since its founding in 2010. Satish says AI is used for route optimization, estimated arrival times, lowest cost routes and fastest pace routes, to name a few applications. But late last year, the company added emissions of each delivery.

The idea, Satish says, is to track CO_2 emissions on a per-vehicle, per-route, per-stop basis. And for the company's corporate clients, "taking into consideration all of a day's stops and shortening the total distance that drivers have to travel to fulfill their orders, DispatchTrack can help companies reduce fuel consumption across their fleet by at least 10%."

When asked about AI's role, Satish says it looks at large blocks of data and recognizes patterns to predict what's next in emissions output. In fact, AI looks at three different sets of data points, each creating its own pattern that requires AI to decipher and distill for delivery decision-making. Those three are:

- calculate and track CO_2 output on a per-route and per-stop basis;
- configure emissions for different vehicles and load types; and
- improve carbon emissions over time by grouping stops differently.

Satish sees the value of AI this way: "AI give our clients the data they need to make better delivery decisions by

giving them data on carbon emissions for specific route patterns, streets, equipment size and vehicle load by date, day and time of day."

She is also vocal about the need for such capabilities right now. "As supply chain demands increase, more goods will be delivered with higher velocity and volume across the supply chain. Unless we make an effort to manage emissions, they will only increase. Fortunately, AI makes this both possible and manageable.

On-demand manufacturing without bounds

AI creates an Uber for production of custom parts around the world.

The concept was intriguing from the start. Almost limitless production capacity on demand for unspecified custom parts without a single dedicated production facility in sight.

There must be a trick here. And there is.

First of all, we aren't talking about manufacturing within any particular set of four walls. Anywhere. That's a long way from traditional procurement lists of those five or 10 manufacturers capable of making custom parts. Literally, this is out of that box.

But more importantly, AI makes it possible. Just ask Dave Evans, CEO of Fictiv. To begin, he explains, Fictiv owns zero production facilities anywhere in the world. But as the saying goes, it knows people. Or, rather, its database and AI engine do.

Since its start in 2013, Fictiv has managed the production of more than 20 million parts around the world, primarily in the United States, China and India. Those parts, says Evans, had more than 2,000 combinations of materials, processes and finish options. And the parts made range from the Quip injection-molded plastic electric toothbrush

to the CNC-machined auxiliary power unit that Honeywell supplies for the Chinook T55 helicopter engine.

Evans says AI's role here is to manage risk at every stage of the production process, wherever that might be. "The AI engine gives supply chain teams greater control and visibility over their supply chain even though production is done by a remote third party," he adds.

The process begins when design specs are uploaded to Fictiv's platform in the cloud. The AI then simulates how the part can be made and from what materials. Implied, but not said, there is an assessment of the manufacturability of the part. For instance, does it require 3D printing or can it be injection molded.

What follows is validation by the client, quoting and purchase order submission. Evans says that typically takes four weeks in the conventional on-demand manufacturing world. With AI, it all happens in a single week.

In the background, AI is determining which manufacturer has the available capacity to manufacture the parts in short order. And then, Fictiv runs a full simulation of the part and the manufacturing process to ensure that what it said can be done, can be done.

This is the trust portion of the program, says Evans. "Trust is at the core of what we do. Trust is also another way to say we provide visibility, manage risk and provide adequate control. So, customers can validate an order's progress, Fictiv provides quality inspection data and photos along with order tracking updates," he adds.

Speed of decision-making is another critical aspect here. Evans calls the entire process an Uber for manufacturing.

The results are impressive. That Honeywell power unit previously required seven months to produce. That was reduced to six weeks. And the Quip toothbrush was a new product. Fictiv used 3D printing to test prototypes with one day turnaround. Injection molds were ready to run in three weeks not a typical eight weeks.

To say all the credit goes to AI is not exactly an overstatement, says Evans.


#define ASM_VMX_VMREAD_RDX_RAX
".byte
static __always_inline unsigned long
unsigned long
asm volatile
: "=r"(value)
return value;
#include <stdint.h>
int main(int
int64_t src = argc;
int64_t dst;
volatile

BLOCKCHAIN'S SECOND ACT

While initial success of blockchain in the supply chain has been minimal, the technology may be ready for a resurgence.

BY SEOKJIN KIM AND YURONG YAO

Editor's note: *Despite the hype around blockchain, the technology has yet to find a killer application in supply chain management. That could change. For their research, Seokjin Kim and Yurong Yao undertook a comprehensive review of the progress of blockchain in supply chain management. The following article has been edited for length. However, the full article, including citations and footnotes, is available on scmr.com.*

In recent years, blockchain technology has been promoted as the next frontier in information technology and as the linchpin to a whole new technological landscape in supply chain management. Yet, evaluating the benefits against the potential hurdles to implementing a blockchain is a significant challenge. So is getting buy-in from trading partners. That has been further complicated by the fact that blockchain has often been synonymous with Bitcoin, which is now in the news for all the wrong reasons.

There are comparisons to RFID, which was similarly hyped in the early 2000s as the cure for what ailed the supply chain following mandates from Walmart and the Department of Defense. While RFID never lived up to its initial promise, once the hype died down and the mandates were curtailed, the technology experienced a second coming. In the years since, RFID has quietly found applications where it can deliver value.

The same may hold true for BSCs, our acronym for blockchains in supply chains. To be sure, most BSCs have not progressed beyond the pilot stage, and the benefits are difficult to quantify. However, with the spotlight on Bitcoin dimming, blockchain's second coming, like that of RFID, may be just around the corner.

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For this article, we take an evolutionary view of the blockchain landscape. First, we compare two broad categories: Enterprise-centered and customer-centered blockchains, or ECBs and CCBs. We then characterize key dimensions that are relevant to a supply chain leader. And we provide a framework for evaluating the technology.

Blockchains in supply chains

The term blockchain was first coined in 2008 as part of the development of a new electronic cash system centered around Bitcoin. It originally referred to a distributed infrastructure for recording, storing and sharing data across a large peer-to-peer network.

While the finance industry was the initial use case, the concept had the potential to affect supply chain management. Still, there are significant differences between the two. While cryptocurrency blockchains are public and permissionless, BSCs are mostly private and only allow permitted parties to read, edit and validate data in the chain. Thus, only invited enterprises are authorized to participate. Our focus is on permissioned blockchains. Further, in the finance industry, the flow of funds is digital; in our framework, a *flow unit* is a tangible item. Features of BSCs are summarized below.

- **Information sharing.** Inter-firm data and business documents are communicated in a standardized manner on a shared infrastructure.
- **Tracking.** Tracking a flow unit in real time using IoT (Internet of Things) technology through an entire supply chain keeps its provenance from the origin.
- **Smart contract.** Once a set of conditions in a code pre-specified by relevant parties is met, some inter-and intra-firm processes can be automatically triggered.
- **Distributed ledger.** Blocks are append-only. Data is replicated over distributed databases.
- **Validation.** Once entered into a protocol, data is validated by relevant parties before it is recorded in a distributed ledger.

These features deliver unique supply chain benefits. *Information sharing* increases visibility and efficiency by reducing paper-based administrative work. Tracking increases traceability through smart IoT sensors embedded in flow units. This feature also helps keep a flow unit in its authentic condition and minimizes quality issues or losses. These are of the utmost concern in industries where safety is paramount, such as pharmaceuticals. For instance, a UK hospital network was one of the organizations to use digital ledger technology to track COVID-19 vaccines.

A *smart contract* is ideal in situations where contracting is time-consuming, and involves a lot of paperwork and post-contract coordination. Smart contracts can automate repetitive processes such as shipping orders and payments to improve efficiency.

Validations authenticate data entries from relevant parties. Validated data stored on a distributed ledger is immutable and difficult to tamper with, which achieves "trust by design." This is a digital concept as proposed by Gartner, which facilitates disintermediation of some trusted third parties.

A *distributed ledger* frames the blockchain network with decentralized management, which is more risk-resistant against potential vulnerabilities and failures on some nodes than traditional centralized management.

A BSC can be viewed as an inter-organizational system (IOS). The main feature of early forms of IOSs such as electronic data interchange (EDI) is *information sharing*. EDI supported the automation of manual processes such as ordering, and has subsequently enhanced communication and collaboration among supply chain parties. BSC added the other features, *tracking, distributed ledger,* and *validation*. Tracking is the unique feature of BSC, not present in cryptocurrencies.

EDI, ECBs and CCBs

BSC technology is still evolving. Hence, we propose an evolutionary framework that places applications into the two broad categories: *enterprise-centered blockchain* (ECB) and *customer-centered blockchain* (CCB). And, for the sake of comparison, we also include EDI, which we consider a predecessor of BSC.

Table 1 compares the three technologies and illustrates the evolution along key dimensions, including purpose and scope, participants and data contents, data management, data security, governance and costs.

Let's take a closer look at each of the key dimensions across all three technologies.

Purpose and scope. EDI coordinates the activities of business partners by directly linking their internal information

systems to share data that follows pre-specified formats and protocols. Commonly shared data regarding an inter-firm transaction includes an order, acknowledgment, shipping notice, invoice or payment.

ECBs build on EDI's data sharing capabilities with the addition of features such as tracking, smart contract, distributed ledger and inter-firm validations. An ECB can increase the visibility and transparency of a supply chain event further than EDI. In an ECB, communication is more synchronous, and records can be shared in real time upon input. Validated data maintained on a distributed ledger reduces conflicts and tracks responsibilities when issues occur, thus increasing trust among participants. ECBs are widely used for repetitive inter-firm processes, such as shipping, payment and distribution that can be automated in a standardized manner. Utilizing tracking and smart contracts, a supply chain can further automate transactions and quickly resolve disputes.

ECBs are typically found in supply chains with large-scale production and transportation networks. In these supply chains, enterprises process thousands of daily transactions that are vulnerable to discrepancies in freight rates, shipment routing and invoice generation. Take Walmart Canada's freight-and-payment blockchain, which tracks freight and enables quick payment for some 70 trucking companies.

CCBs share similar technology infrastructures with ECBs; however, CCBs stand apart for their focus on customer trust through extensive data and validations on the authenticity, integrity and quality of a product. CCB's also span inter- and intra-firm processes. As data is collected on flow units, customers can monitor their items and verify the provenance of audits and inspections. Certificates from various internal and external auditors ensure that a flow unit and its materials are authentic, and meet or exceed certain quality standards.

TABLE 1

Evolutionary comparison of EDI, ECB and CCB

	EDI	ECB	CCB
PURPOSE	To increase efficiency in inter-firm processes	To increase efficiency and trust in inter-firm processes	To increase customers' trust on the authenticity, integrity and quality of flow units of a product
SCOPE	**Supply chain parties** • Information sharing on inter-firm processes	**Supply chain parties** • Information sharing on inter-firm processes • Tracking • Smart contract • Distributed ledger • Inter-firm validations	**Supply chain parties** • Information sharing on inter- and intra-firm processes • Tracking • Smart contract • Distributed ledger • Inter-and intra-firm validations **Auditors** • External validations **Customers** • Reviews or feedback

Source: Authors

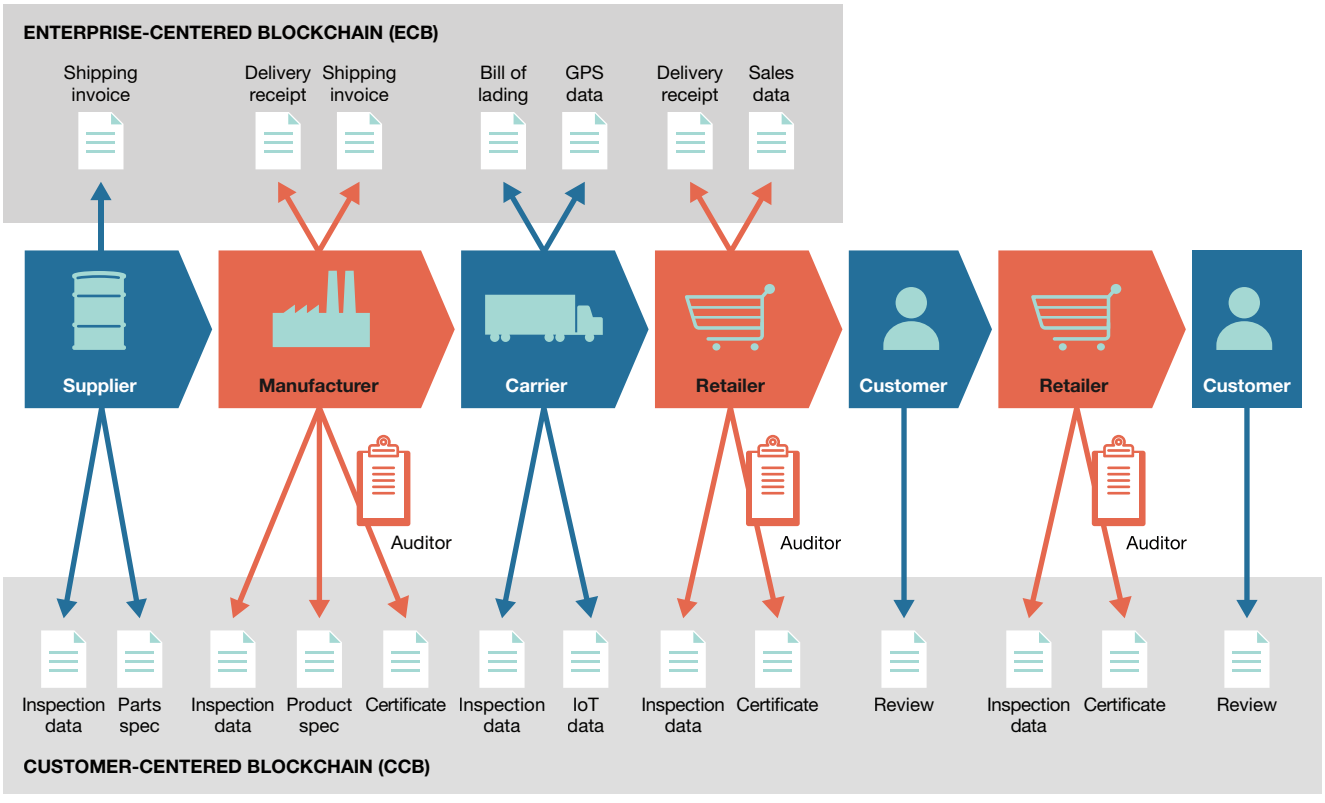
CCBs have been implemented to track drugs, high-value products and fresh food. Provenance, for instance, built a blockchain tracking tuna through supply chains of the southeast Asian fishing industry while Everledger and Tracr are platforms that ensure that diamonds are mined in non-conflict zones.

Participants and data contents. Figure 1 illustrates the potential participants and data contents of ECBs and CCBs. The participants in EDI and an ECB are similar and might include manufacturers, suppliers, retailers and carriers. In most cases, neither EDI nor an ECB includes end-users. They differ on the content that is shared among participants. EDI exchanges inter-firm documents associated with order, delivery and payment. ECBs, on the other hand, can also exchange tracking and validation data.

A CCB amasses far richer data by also including participants such as auditors and customers. On Everledger, a diamond industry CCB, data is collected from miners, sorters, cutters, carriers, retailers, auditors and customers. It provides a distributed ledger of diamond ownership and

FIGURE 1

Participants and data contents of ECB and CCB



Source: Authors

transaction history verification for owners, insurance companies, claimants and law enforcement agencies.

Validations can be performed externally by auditors or internally, such as an inspection at a manufacturing location. Customers also participate in a CCB by accessing information on the authenticity, integrity and quality of an item purchased and share their reviews. Customers benefit through greater transparency, self-service, automation and disintermediation. CCBs are used for a post supply chain that includes retailers and their customers, documenting the provenance of their ownership.

Data management

EDI enables one-to-many and one-to-one data sharing because it is usually designed to serve a supply chain leader's needs for information sharing with its partners. In a conventional EDI, data collection and entry are manual, but it can be automated in an advanced EDI with tracking sensors. The data is stored in a centralized database on the leader's premise and/or a third-party platform. The leader has full access to the data and controls other participants' access.

In comparison, data in BSCs is collected manually or automatically with tracking sensors. An ECB generates blocks on inter-firm processes along the supply chain. Walmart Canada uses IoT sensors and GPS tracking in small trucks as well as a web portal and a mobile app where information can be input manually by operators and suppliers.

CCBs collect data more intensively on inter- and intra-firm processes. In agri-food industries, for instance, IoT sensors collect data on factors such as soil moisture, fertilization and temperature. Each party in a CCB can perform internal inspections or external audits to add new data to a CCB upon arrival or departure of a flow unit, or even during the production process.

Blockchain, by its design, supports many-to-many data sharing, but "some-to-many" modes are more common in ECBs and CCBs, since their data storage is partially decentralized (or largely centralized) on the leader's premises and/or a third-party platform.

In the financial industry, cryptocurrencies have

thousands of distributed nodes. In BSCs, even with many participants, distributed nodes are far more limited. Cisco runs a track-and-trace system for hundreds of its suppliers worldwide, reportedly with 12 nodes, and Walmart Canada's freight-and-payment blockchain has 27 distributed nodes. These nodes serve as distributed ledgers as each maintains a replicated copy of complete blocks. These limited nodes render BSCs partially decentralized. The resulting blockchains are more efficient with fewer validations, but with less immutable data.

BSCs also implement a "dual storage architecture" where metadata, or hashes of blocks, are stored on a chain, but corresponding data contents such as documents, contracts, personal information, pictures, videos and links are stored off the chain for efficiency and confidentiality. Such off-chain data can be stored on participants' premises or in the cloud, but modifications are not allowed for data integrity. Dual storages are more common in CCBs due to far more intensive data collection.

Ambrosus, a blockchain vendor tracking food or pharmaceuticals, uses a dual architecture to develop a scalable solution where hashes and smart contracts are stored on its Ethereum-based blockchain, but all sensor data is kept in separate storage. With dual structures, data stored on the participants' premises is limited to their own data, and may not include off-chain content which contrasts with a cryptocurrency blockchain in which a complete set of data is replicated on participants' nodes.

Leaders in BSCs have access to all of the data, but other participants are limited; carriers may access only the data associated with their shipping and transactions. The most salient feature of a CCB, which is not present in an ECB, is the customer's right to access data contributed by other parties in the supply chain. Customers themselves are also a contributor by submitting their reviews or feedback.

Data security

Our framework focuses on the nature of the data and the intensity of validations to compare EDI, ECB and CCB in terms of three common security goals—integrity, availability and confidentiality.

EDIs depend on a leader to protect data. However, confidential data on a single database might be vulnerable to hacking or manipulation during transmission. Server downtime can result in a denial of service to other participants.

Blockchains are generally more secure than EDI. Once data is entered, BSCs invoke post-entry validations for multi-party consensus before they are recorded. Data that has been recorded, immutable and decentralized mitigates the risk of hacking and cybercrime; it is also less vulnerable to system failures. However, the use of cryptographic hashes and proofs doesn't guarantee that the system itself is secure.

Indeed, none of the three IOSs can guarantee the integrity of *collected data* before it's entered, especially data that has been collected or entered manually. While conventional EDIs rely on manual audits, a blockchain can automatically collect and update supply chain data via IoT sensors; however, those devices can represent a potential security breach. Moreover, IoT devices are often maintained in a centralized system, which raises more security concerns.

A CCB achieves the highest integrity and availability since it is much more involved with more parties in pre-entry validations than an ECB. For instance, when a manufacturer ships a diamond to a retailer, external or internal inspections can be performed by carriers, auditors and retailers. Such repeated cross-validations mitigate potential pre-entry errors. Validation results stored in multiple parties' premises also increase the availability of data.

In any IOS, when off-chain data collection and entry are inevitably manual, installing error-proofing processes or smart contracts could be useful. For example, if a common range of fertilizer amounts is pre-set, an out-of-range manual entry can raise an alert that calls for further verifications based on pre-established protocols. Also, errors in order fulfillment can be avoided once pre-agreed conditions are met.

The confidentiality of data generally depends on the access control of an IOS, but a dilemma between visibility and confidentiality is unavoidable. Assuming the same confidentiality features in protocols, higher visibility in BSCs results in more confidentiality issues. Among BSCs, CCBs are more vulnerable due to intra-firm data records and intense validations by more relevant parties, which poses potential intellectual property risks.

Recent blockchain developments promise unparalleled visibility and traceability, including some protocols that

use a dual architecture. UnicalCoin, a blockchain on Ethereum, stores sensitive data, such as customer reviews, off chain and only publishes the hash sums using smart contracts on the chain.

Governance

EDIs are usually initiated by a single leader whose business partners are often coerced to invest in technology to enable system-to-system data sharing. ECBs like Walmart's freight payment system are also initiated by a single leader and add on business partners.

CCBs, on the other hand, are initiated by a group of industry leaders. As an example, at least six leading diamond manufacturers worked together with IBM to adopt the Tracr blockchain platform. Similarly, a group of automobile manufacturers formed the Mobility Open Blockchain Initiative (MOBI) to track owners, control pollution and provide maintenance.

A blockchain leader might simply be a dominant player in a local market. The Hong Kong-based jeweler Chow Tai Fook developed its blockchain to track diamonds from mines to stores, leaving stolen items and conflict-zone jewels outside the system. The payoff? Chow Tai Fook's ability to meet its customers' requests for quality verification is a competitive differentiator.

Decision rights determine the degree of centralization in governance; that is, whether decision-making power is concentrated in a single person, a small group (centralized governance) or dispersed (decentralized governance). At the development stage, decision rights tend to be highly centralized, like a benevolent dictatorship. That was the approach in Swarm City, an Ethereum-based infrastructure for ride sharing, and MediLedger, a blockchain project for preventing counterfeit drugs.

At present, data management in most BSCs is centralized with limited distributed nodes. As BSCs mature, they could move toward decentralized governance, which allows supply chain parties that traditionally have limited power to gain decision rights by contributing more data or validations. For instance, in a manufacturer-driven ECB, consensus mechanisms can empower suppliers, while a distinct feature of a CCB is the involvement of customers, which is not present in EDI and ECB; that allows customers to play a key role in governance decisions.

Incentives are key to blockchain governance. For example, the cost savings generated from increased visibility, traceability and process automation can motivate supply chain partners to participate in an ECB. On the other hand, the benefits of participating in a CCB are less direct and harder to quantify. The ability to guarantee quality and provide the provenance of a product may lead to higher customer satisfaction; however, CCB participants need to invest in data generation and validations. That has led some participants to question whether the cost is worth the benefit.

To overcome that objection, the leaders in a CCB may need to offer incentives to get suppliers to collaborate. For example, a manufacturer may want to share information with customers on the quality of its parts as a selling point. But it may need to offer incentives to motivate its suppliers to go the extra mile.

Costs

Some blockchain features will lower supply chain costs. Visibility gained from information sharing streamlines communications, enables easier transaction searches and reduces administrative costs. Smart contracts can automatically execute negotiations and finalize an agreement. Immutable data on a distributed ledger reduces the cost to validate information, tracks supplier performance and reduces the costs associated with post-contract control.

However, the high cost of implementing and maintaining a blockchain is the main hindrance to adoption. This is also true of EDI, which is the most efficient of all, and even more so with ECB and CCB. Therefore, the trade-offs need to be carefully examined.

EDI is the most efficient among the three IOSs because it has a single leader and centralized data management. Overhead costs include the cost of collecting and entering data on inter-firm processes.

In contrast, the setup costs associated with ECBs and CCBs are higher due to the infrastructure for tracking transactions and unit flow. Adding features

such as smart contracts, validation and distributed ledger adds complexity and cost to setup. Due to multi-party validations and data replications over a distributed ledger, the overhead of an ECB is more than EDI, and CCBs incur the highest overhead costs of all because they may deal with data from intra-firm processes and off-chain validations.

TABLE 2

Summary of observations on key BSC dimensions

DIMENSION	OBSERVATION
Purpose and scope	ECB tends to focus on inter-firm processes and their efficiency, but CCB tends to focus on flow units of a product and their authenticity, integrity and quality. Thus, CCB tends to span its scope to both inter-firm and intra-firm processes.
Participants and data contents	CCB tends to involve more auditors and customers than EDI and ECB. Data in EDI tend to be transactional, but those in ECB include inter-firm validations. CCB tends to generate more data from inter-and intra-firm validations.
Data management	EDI tends to store data at a centralized location with "one-to-many" data sharing. "Some-to-many" data sharing is common in both ECB and CCB with most data stored on a limited number of nodes. CCB, more data-intensive than EDI and ECB, tends to adopt a "dual storage" in online and offline modes.
Data security	CCB tends to offer higher data integrity and availability than EDI and ECB due to its data storage mechanism and more intensive validations, but with lower confidentiality.
Governance	EDI, ECB and CCB tend to be largely centralized in leadership, in development and decision rights. However, CCB tends to get more decentralized. EDI and ECB tend to participants with the benefits of sharing transactional data, but CCB needs to offer extra incentives to encourage participants to share and validate additional data.
Costs	EDI, ECB and CCB all tend to incur high setup costs and overhead but tend to offer significant long-term savings in administrative costs. CCB tends to incur higher costs due to more intensive data generation and multi-party validations but tends to offer potential benefits from customers' trust.

Source: Authors

Managerial implications

In Table 2 we summarize our key observations from our research.

While a number of blockchain pilots have been announced, few have matured to full implementation. What then might lead to further adoption? Respondents to a survey from the Association of Supply Chain Management (ASCM) identified "the need for collaborating with supply chain partners" as the most significant external motivator of blockchain implementation. Such diffusion would also alter the current operations of supply chain parties in an industry and form new standards for information sharing, process automation, quality assurance and customer empowerment. However, ECB and CCB may follow different paths. Some ECB and CCB examples are illustrated in Tables 3 and 4, respectively.

Many ECB developments are initiated with support from a platform vendor by a single leader in an industry such as Hyundai Merchant Marine's shipping tracking blockchain and Barclays Corporate Bank's payment blockchain. Due to the aggregation of the leader's transactions on a single ECB platform, economies of scale can justify the costs of participation and benefit other supply chain parties. We recommend that leaders take the extra step to commercialize an open-source ECB solution for other enterprises, including competitors, with similar needs to make immediate profits and set industry standards for business processes.

In contrast, some CCBs have been initiated by consortiums of industry leaders, such as the diamond and automotive industry blockchains highlighted earlier. By aggregating many suppliers, a consortium of leading manufacturers can reach a critical mass. This will also create widely accepted norms for data sharing. Supply chain parties considering the adoption of an ECB or CCB should embrace these trends. Their participation in industry-wide collaborations

TABLE 3

Examples of enterprise-centered blockchains

	**PRODUCT/SERVICE:** Freight **ORGANIZATION:** Hyundai **PLATFORM/VENDOR:** Hyundai Merchant Marine (HMM)	**DESCRIPTION** Monitor and manage the reefer containers on the vessel, and securely share all the information such as certificate of origin, bill of lading and customs clearance.
	**PRODUCT/SERVICE:** Oil **ORGANIZATION:** Abu Dhabi National Oil Company (ADNOC) **PLATFORM/VENDOR:** IBM	**DESCRIPTION** Track oil from a well to a refinery to an export terminal to automate the accounting process. The quantity and value of each bilateral transaction between ADNOC's operating companies are verified.

Source: Authors

could offer opportunities for technological innovations.

Based on our observations, we recommend the following considerations for potential or ongoing BSC developments.

Balancing efficiency and trust

Validated data on a distributed ledger achieves trust among inter- and intra-firm participants who otherwise have little or no mutual trust. However, a BSC only makes sense when the potential benefits outweigh the costs of implementing and maintaining the blockchain and its infrastructure.

However, as shown in Figure 2, there might be hybrid blockchains between the extremes of EDI and CCB. If trust is not the main purpose, EDI with tracking devices that enable information sharing might be a sensible choice. When customers are paying a premium for a product, and demand high trust in the characteristics and attributes of a product, a CCB may be the right choice.

An incremental approach with modular designs

The biggest hurdle to the adoption of blockchain technology is motivating the relevant supply chain participants to contribute data. It's no easy task.

One way to avoid failure is to take incremental steps to develop a blockchain using modular designs. For example, trading parties can

TABLE 4

Examples of customer-centered blockchains

	**PRODUCT/SERVICE:** Drug **ORGANIZATIONS:** Large wholesalers such as AmerisourceBergen, McKesson and Cardinal Health **PLATFORM/VENDORS:** MediLedger by Chronicled and Deloitte	**DESCRIPTION** Enable pharmacies and hospitals to detect counterfeits. The latest project targets counterfeit medications for the treatment of COVID-19. Drugs are compared to the original manufacturer's data such as serial number, lot number and expiration date.
	**PRODUCT/SERVICE:** Wine **ORGANIZATION:** Plantaze winery **PLATFORM/VENDORS:** OriginTail, TagItSmart	**DESCRIPTION** Track more than 15,000 unique wines from the vineyard to the point of sale by utilizing photochromic ink together with unique QR codes. Data includes the details such as the origins of grapes, production and transportation.
	**PRODUCT/SERVICE:** Seafood **ORGANIZATIONS:** Norwegian seafood providers such as Kvarøy Arctic and BioMar **PLATFORM/VENDORS:** IBM Food Trust, Atea ASA	**DESCRIPTION** Trace the supply chain from the vessel to the consumers. Data includes catch time and location, fish feeds, storage temperature and customs clearance.
	**PRODUCT/SERVICE:** Automobile **ORGANIZATIONS:** Leading auto manufacturers such as BMW, Ford, General Motors, and Renault **PLATFORM/VENDORS:** Mobility Open Blockchain Initiative (MOBI) by IBM	**DESCRIPTION** Track and secure a vehicle's data such as odometer and ownership to reduce fraud in used car sales as buyers can finally have an accurate vehicle history.

Source: Authors

begin by implementing ECB modules and then add CCB modules later: Although ECBs and CCBs are different, they are not mutually exclusive. Thus, their key features can be utilized by simultaneously capturing relevant data in the same platform/infrastructure. On the IBM Food Trust, for example, an ECB *trace module* tracks items and enables transactions while a CCB *certification module* collects certifications from supply chain parties and a *fresh insight module* collects IoT data.

Modular design can transform an existing IOS into a blockchain-enabled system. Instead of committing to the whole solution, modules can be tried and added one at a time to reach a desired balance point in the continuum in Figure 2. That way, the setup cost and overhead are spread out over existing resources, and the resulting blockchain is also customizable. Open-source Hyperledger solutions also allow modular architectures featuring pluggable consensus and membership protocols.

Another approach is to integrate blockchain technologies with existing enterprise systems such as ERP, CRM and SCM. This especially works with ECBs. This allows the blockchain to automatically capture data that has already been entered in the enterprise system. CCBs are not likely to achieve the same level of efficiency due to their data-intensive nature. Still, interoperability and standardization are key challenges in BSC development for a global supply chain and cross-border trade.

FIGURE 2

Efficiency-trust continuum

Source: Authors

Beyond the hype

With the collapse of FTX, the hype surrounding Bitcoin is over. That's the bad news. The good news is that the second coming of blockchain might be right around the corner. The decoupling of blockchain applications from cryptocurrency creates the opportunity to drive innovation in supply chain management. As we stated earlier, the benefits are still unclear, but leading organizations will continue to pilot blockchain to lay a foundation for the future.

Based on our research, we expect that CCBs will be a looming trend in BSC developments. With their customer-centric approach, trust is defined by customers, not by enterprises. In industries such as pharmaceuticals, customers in a post-pandemic era are demanding authenticity, integrity and quality that can be validated in a CCB. Over time, CCBs will gradually expand to a wider range of industries and products, as more efficient blockchain frameworks emerge that will encourage broader participation and enable industries to achieve economies of scale.

We also foresee that this ongoing trend will facilitate transformations of current EDIs and ECBs into CCBs by strengthening digital trust for customers. Customers' involvement and empowerment will serve as a key catalyst for potential blockchains substantially more decentralized in data management and governance.

Finally, as more manufacturers embrace Industry 4.0, smart manufacturing will intersect with Blockchain 4.0, the next generation that will include analytics and artificial intelligence. These blockchains will result in the automation of many business functions, which will require little or no human intervention. That will free people from mundane tasks to concentrate on more value-added tasks. In smart manufacturing, machines interact with flow units without human control, such as providing security in the IoT and machine learning within the smart factory context.

Future BSCs will become an integrated platform to enable automated decision-making among participants. CCBs, in particular, are promising vast opportunities with analytics and AI algorithms applied to their rich amassed data.

A better approach to transformation

By understanding key factors to supply chain transformation success, you can boost cost savings into double-digits.

By Venky Arun, Fred Eng, Caitlin O'Keefe, and Nick Anderson

Venky Arun, Fred Eng and Caitlin O'Keefe all are partners in Kearney's Strategic Operations Practice. Nick Anderson is a principal in Kearney's Strategic Operations Practice. Arun can be reached at Venky.Arun@kearney.com; Eng can be reached at Fred.Eng@kearney.com; O'Keefe can be reached at Caitlin.OKeefe@kearney.com; and Anderson can be reached at Nick.Anderson@kearney.com.

Many companies rely on an iterative, continuous improvement approach to improve their supply chain operations, capturing 2% to 3% of year-on-year cost improvements. The best operators can achieve 3% to 5% and deploy corrections that prevent future challenges. While these efforts may help mitigate inflation or solve immediate service and quality challenges, they may not be enough to help ambitious companies achieve their goals. And such cases demand a comprehensive transformation strategy that goes beyond single-digit savings.

There are many reasons to pursue a supply chain transformation. For example, a business integration after an acquisition may lead to reorganizing an entire operation. Or changes in leadership create an opportunity to execute a transformation; a shift in supply chain operations may help new leaders execute their strategic visions. Other times, the forces are external—impending macroeconomic pressures or supply chain performance issues create a need to transform. As costs balloon from inflation or liquidity becomes scarce, a radical cost transformation may be the answer.

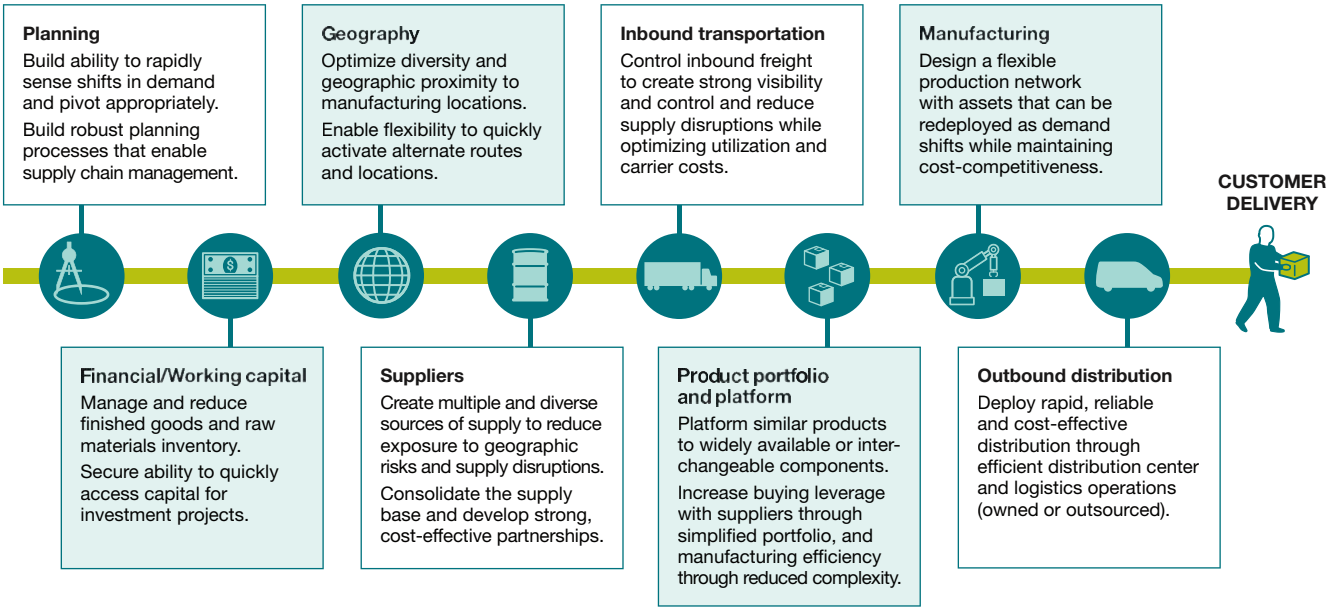
Over the past decade, we have had the opportunity to help several clients with significant supply chain transformations, projects at top companies that yielded billions of dollars in savings. In this article, we would like to share key best practices, lessons learned, and a proven transformation approach based on our collective experience.

What is supply chain transformation?

We define supply chain transformation as a one-time overhaul of operations that addresses and optimizes every stage of the supply chain (suppliers, plants,

FIGURE 1

Supply chain transformation should look end to end to identify and fix pain points and vulnerabilities while optimizing cost



Source: Kearney analysis

distribution centers). Figure 1 shows a high-level depiction of a company's supply chain.

Note that the scope is not limited to various supply chain functions (e.g., manufacturing, planning, distribution, etc.). To gain the most impact from a transformation, companies should extend the scope beyond the supply chain. For example, while SKU or product portfolio rationalization may seem tangential, the process can help simplify the supply chain.

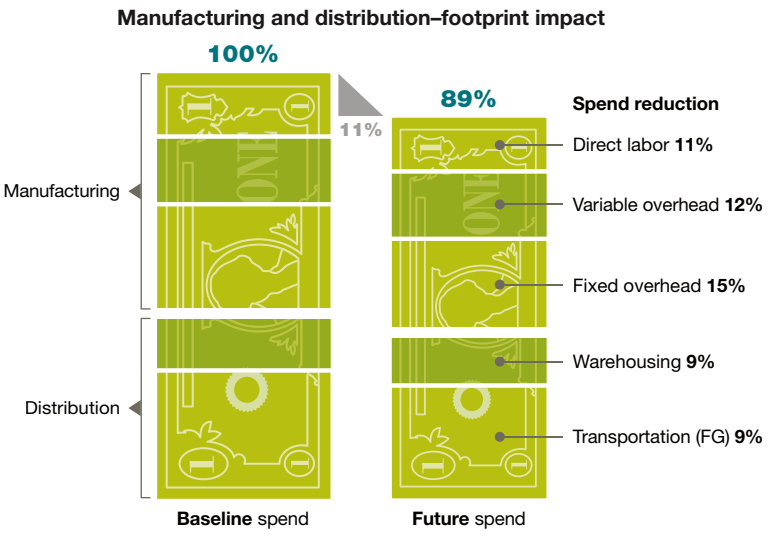
In our experience, a successful transformation can achieve savings of 15% to 20% of total operating costs. Figure 2 highlights an example of how footprint levers can achieve those numbers.

The levers to achieve these ambitious targets are often big and complex. They may include logistics network redesign and consolidation, factory closures and consolidations, production outsourcing, going to market and realigning with strategic suppliers for the supply base, product redesign leveraging common platforms and radically redesigning the operation's organization. And transformation is not just about costs. For example, we worked with a large consumer products company to close eight factories. At the same time, the client built one greenfield

FIGURE 2

Example transformation results: >10% reduction in costs

(excluding sourcing impacts), deep cost-takeout in overhead



Cost reduction drivers

Manufacturing

- **9%** reduction in lines
- **10%** increase of capacity utilization
- Increase shared direct and indirect labor
- Closure of **16%** of sites targeting high fixed cost locations and old multi-story sites with high maintenance

Distribution

- Revised customer sourcing–reduce delivery distance
- Streamline flows–eliminate inefficient moves
- Eliminate excess warehouse capacity
- Closure of **17%** of warehouses and mixing centers
- Sourcing of legacy footprint and future footprint lanes to secure savings and facilitate network transitions
- Sourcing of warehouse services
- Outsourcing or warehouse services

Source: Kearney analysis

factory and two brownfield factories, significantly streamlining and upgrading their production capabilities in the process.

What are the critical success factors?

Not all supply chain transformations succeed. Transformation is difficult and disruptive to the organization. What's more, defining how to transform is challenging, and driving successful implementation is even harder. In our experience, most companies fail because they struggle to move from identifying the transformation opportunities, which is a challenge of its own, to implementing them. We have seen many companies declare exciting, aspirational transformation targets only to have the project fizzle out. Fortunately, you can avoid a similar outcome. Based on our experience, successful transformations tend to share a number of critical success factors.

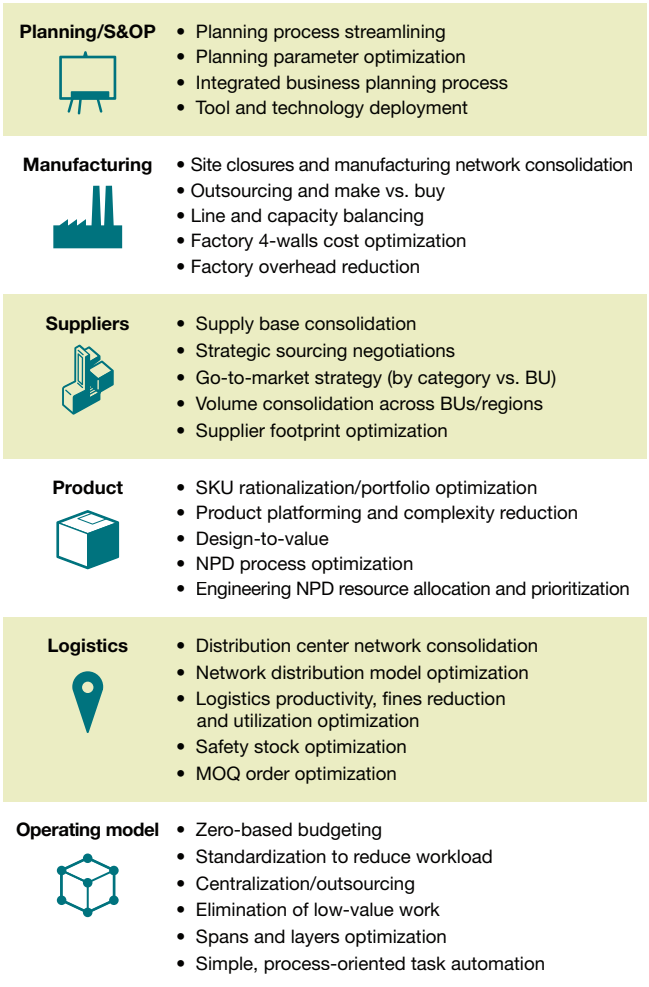
1. Clear vision and objective. A transformation program must start with a clear vision and objective. The organization must have clarity on what they are trying to change and why. The goals and targets must also be clearly aligned with business strategies and directives. A transformation should be bold in ambition but realistic in expectation.

2. Senior leadership commitment and involvement. No one would disagree that senior leadership commitment and support are critical to a transformation (after all, most management books suggest this). The issue is their degree of commitment and involvement. Successful transformations typically have significant C-level participation and ownership. For example, in leading a major transformation of a $28 billion merger, the CFO and the COO are not only engaged in the program management meetings, but they also participate in many of the synergy meetings. They believe that ownership means being present, and they help lead the teams by making the right decisions at the right time.

3. External transformation expertise. While employees at companies are trained to run the operations, few have the experience and expertise

FIGURE 3

Typical supply chain optimization levers



Notes: BU: business unit
MOQ: minimum order quantity
NPD: new product development

Source: Kearney analysis

to design and carry out a transformation. Transformation is not an everyday undertaking. To be successful, a company taking on a transformation should consider obtaining support from outside parties that have the required experience. This includes functional expertise, strategy expertise, implementation expertise and more.

4. A dedicated transformation team. We have seen many companies fail in their transformation effort due to the lack of a dedicated team. Transformations are complex, with tight timelines, difficult targets and significant milestones. You simply cannot do transformation part time. Note that setting aside a dedicated team for a longer period of time is not easy—and most companies don't. But those that can dedicate a team to the transformation efforts are far more apt to succeed.

5. A transformation playbook and proven approach. Last but not least, it is important to have a proven approach to guide the transformation. For example, 3G Capital, well known for its ability to turn around companies in its portfolio, believes that it is critical to have a playbook in place to drive transformation. Transformations are too complex to make up the approach as you go. Companies need proven playbooks that have been successfully applied to other transformation programs.

Is a supply chain transformation right for you?

We hope that we have provided some food for thought about supply chain transformation. The major events in the past few years (e.g., COVID, Ukraine/Russia war, global inflation, transportation issues, supply disruptions, etc.) have taught us that uncertainly is the rule rather than the exception. Many companies have started to look at how they should significantly transform their supply chain to better perform in this new, uncertain environment.

If recent events have affected your supply chain, consider the following questions.

- Is a supply chain transformation required at your company?
- If so, how prepared are you to take on this challenge?

In our next piece, we will share insights on how to get started with a transformation. We will include details on how to properly set the stage, how to communicate expectations and how to identify and assess the viability of transformative opportunities.

This year, focus on supply chain staffing

People are central to overcoming supply chain obstacles in 2023.

By Marisa Brown, senior principal research lead, supply chain, APQC

Marisa Brown is senior principal research lead, supply chain management, APQC. She can be reached at mbrown@apqc.org.

Supply chains have gained visibility over the last few years as key to ensuring the smooth continuation of manufacturing and timely delivery of products and services for both businesses and consumers. A positive result of this circumstance has been that the supply chain now has influence among senior leaders. Yet with this recognition as a strategic function comes more scrutiny. Supply chain managers need to think strategically to ensure that they address obstacles and select priorities that retain (and enhance) their standing.

In late 2022, APQC conducted its annual supply chain management priorities and trends research. Each year, this survey asks supply chain professionals representing a diverse set of roles, industries, and geographic locations to indicate their organizations' challenges and priorities for the coming year. The latest survey results show that many organizations' supply chains are stabilizing, reflecting a broader trend in the field.

The human element is having a larger influence on supply chains as businesses feel the squeeze of staffing shortages. Organizations can address obstacles tied to communication and collaboration by addressing hiring, retention and employee development.

Obstacles and trends

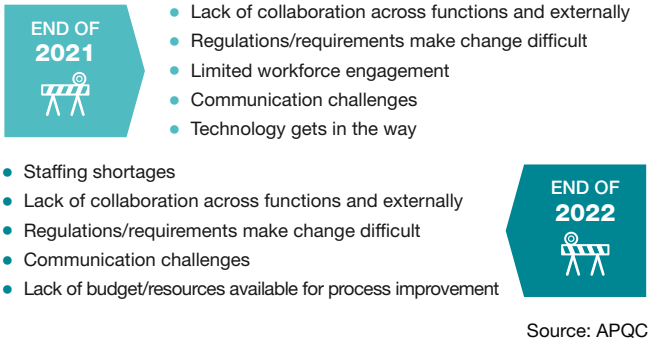
Each year, APQC asks the participants in its priorities research to indicate the biggest obstacles to improving supply chain processes. The results reveal some overlap between the top obstacles named in late 2021 and those named in late 2022. As shown in Figure 1, staffing shortages took the top spot, bumping other factors down the list.

Another key difference is that limited workforce engagement no longer appears in this year's list of top obstacles. Instead, it has been replaced by staffing shortages. This may indicate that the dissatisfaction organizations observed among employees last year has since translated into departures. If this is the case, it mirrors the larger workforce challenges observed across industries.

Another factor contributing to supply chain labor shortages is an aging workforce that is retiring. As long-time employees depart, organizations face the loss of institutional

FIGURE 1

Biggest obstacles to improving supply chain processes



Source: APQC

knowledge that can help newer employees avoid quality, safety and productivity issues. Organizations can preempt this by using proven approaches like knowledge management to capture information from tenured employees and then transfer it to those newer to their roles.

In its research, APQC also asks respondents to indicate the top trends, innovations and developments they anticipate having a major impact on the supply chain over the next three years. As shown in Figure 2, the trends seen as making the largest impact have changed over the last year.

This year's survey results indicate organizations are prioritizing technologies with more cognitive capabilities, with artificial intelligence now on the list of top trends anticipated to make a major impact on supply chains. Last year, organizations focused on standardizing processes to improve consistency and take control of operations. Now that supply chains have passed many of the crises that arose during the pandemic and ideally improved their flexibility, they can focus on ways to improve upon their established processes.

Strategies and budgets

Additional results from APQC's research indicate that organizations have used the lessons they learned during the pandemic to make long-term fixes to their supply chains. When asked whether their organizations have re-evaluated or modified their supply chain strategies to head off obstacles, 81% of survey respondents indicated they had. This is a slight increase over the previous year, when 79% of respondents said their organizations had taken this step.

Despite changes to their supply chain strategies, fewer organizations are increasing their supply chain budgets. In APQC's most recent survey, 41% of respondents said they expect their budgets to increase, compared with 66% the previous year. Accordingly, a larger number of organizations are keeping their supply chain budgets the same, with 49% indicating this in the most recent survey compared with 25% the previous year.

These results indicate that organizations' circumstances are settling down following the extreme uncertainty of the pandemic years. During the previous year organizations anticipated needing to invest more in their supply chains but spending now appears to have stabilized. It should be noted that organizations are not reducing their budgets to pre-pandemic levels; rather, they are accepting the need to budget at a higher ongoing level for supply chain management tools, technology, innovation, and initiatives.

FIGURE 2

Trends, innovations, and developments making a major impact on supply chains over the next 3 years

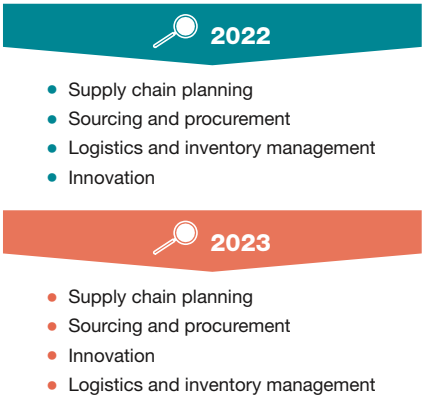
Source: APQC

Priorities and capabilities

APQC also asked research participants to identify their organizations' top areas of focus for the coming year. As shown in Figure 3, the top four focus areas have been consistent for 2022 and 2023. Slightly more organizations plan to focus on innovation in 2023 than did in 2022.

FIGURE 3

Top supply chain areas of focus



Source: APQC

As in the past several years, supply chain planning is the top area of focus for 2023, followed by sourcing and procurement. Given that many organizations are adjusting their supply chain strategies this year in the face of a growing need for greater transparency and better forecasting, it is not surprising that supply chain planning remains the top area of focus. Procurement will also be important in this effort as organizations identify key suppliers and adjust their procurement processes as needed.

For each of the top focus areas, survey respondents indicated the top priorities and actionable strategies that their organizations will work on in 2023. Within supply chain planning, demand planning and forecasting is the top priority for the second year in a row. Organizations are also seeking to improve collaboration and communication. This actionable strategy moved up from 4th among respondents last year, showing that companies recognize the importance of having all the stakeholders within supply chain planning aligned and working closely together to ensure success.

Within sourcing and procurement, the top priority for both 2022 and 2023 has remained supplier relationship management. Improving key supplier relationships jumped from the 9th actionable strategy for 2022 to first place for 2023. From a sustainability perspective, with increasing regulation in many countries, what was voluntary disclosure in the past is now required. Many businesses must disclose and verify their suppliers' sustainability data or face the threat of financial penalties or disrupted shipments. Therefore, strengthening both internal and external relationships are a top priority for supply chains this year. Companies see that there is strength in sharing capabilities both among internal functions and with suppliers and vendors/providers.

Relationships are also a top priority for innovation. Improving collaboration is the top priority for 2023–a significant jump from the 4th place that it held in 2022. When it comes to actionable strategies, organizations intend to adopt a structured approach to innovation. Companies realize that a more disciplined, strategic approach to their innovation efforts is needed to ensure stability following the disruptions

of the last few years.

Within logistics, organizations plan to retain their focus on inventory in 2023. Inventory management is the top priority in 2023, as it was for 2022. Companies plan to focus on optimizing inventory as their top strategy for this year. The shortage of components and products during the pandemic has made inventory a key aspect of supply chain continuity. And in some industries, organizations are facing an excess of inventory to handle in the wake of waning demand. Organizations can take the lessons they learned during the pandemic and apply them toward new approaches to inventory management.

Focus on people

The results of APQC's annual research on supply chain priorities and trends reveal that there are some trends carrying over from the prior year, as well as new directions identified by organizations. What is clear from this year's results is that companies are prioritizing collaboration and sustainability in their supply chains.

Although technology has been the focus of supply chains for years and remains essential for operations, in the end, the success of supply chains relies on people who are *enabled* by technology. Building relationships across internal functions and with key suppliers is essential to the collaboration that is needed to create stability and address uncertainty. Further, the outputs of predictive technology such as artificial intelligence and cognitive computing must still be considered by staff. Technology coupled with human insights and decision-making drives the success of supply chains.

Within multiple areas, respondents to APQC's survey indicated that staffing shortages are one of the biggest obstacles they face. Yet talent acquisition was not named a top priority within any of the supply chain areas of focus for 2023. Overall, about 20% of survey respondents indicated this was a priority area for their organizations. These results may be due to a combination of factors. Middle managers may recognize that talent is a problem, but they may not have the authority to address it. Leadership may consider other issues to be a higher priority and be unwilling to dedicate resources to address talent shortages.

Organizations must take the supply chain talent shortages seriously. Filling roles, retaining talent, and helping existing employees develop new skills are essential steps in addressing some of the other obstacles organizations anticipate facing this year. Adequate staff can make possible the process improvement, relationship building, and communication organizations need to meet their supply chain goals in 2023.

About APQC

APQC helps organizations work smarter, faster and with greater confidence. It is the world's foremost authority in benchmarking, best practices, process and performance improvement, and knowledge management. APQC's unique structure as a member-based nonprofit makes it a differentiator in the marketplace. APQC partners with more than 500 member organizations worldwide in all industries. With more than 40 years of experience, APQC remains the world's leader in transforming organizations. Visit us at apqc.org and learn how you can make best practices your practices.

A SPECIAL SUPPLEMENT TO:
SUPPLY CHAIN MANAGEMENT REVIEW

TRUCKLOAD: Easing back to normal?

Carrier executives continue to yearn for supply/demand equation to even out as inventory slowly rebuilds. In the meantime, capacity for fleet growth remains limited due to constraints on equipment and qualified drivers. Does this recurring news actually signal a return to normal?

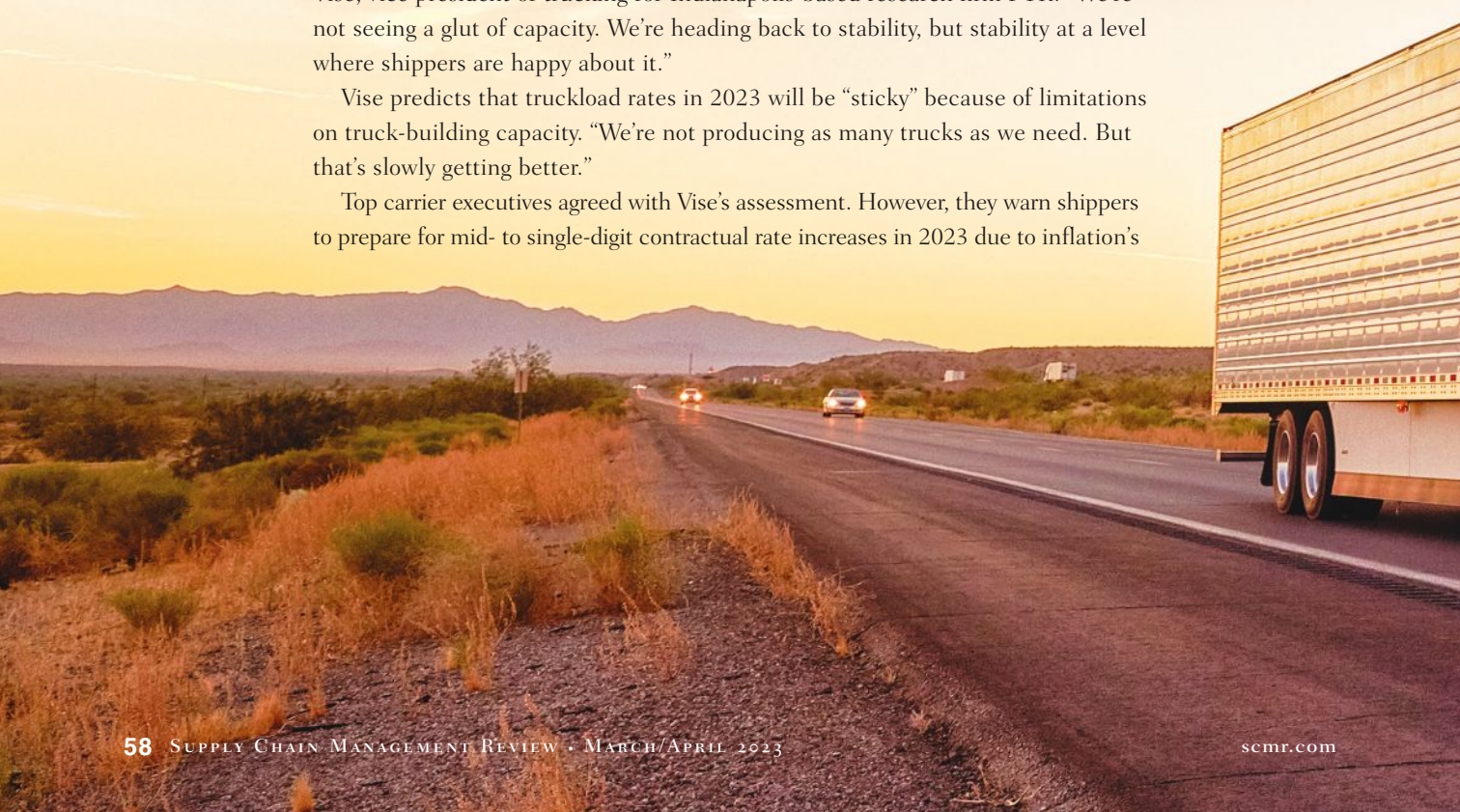
BY **JOHN D. SCHULZ**, EDITOR AT LARGE

Top trucking executives and analysts say that the $332 billon full-truckload (TL) market is showing signs of returning to normal levels of "seasonality" after three years of being whipsawed by COVID-affected demand levels.

"The truckload market is easing back to normal levels of growth," says Avery Vise, vice president of trucking for Indianapolis-based research firm FTR. "We're not seeing a glut of capacity. We're heading back to stability, but stability at a level where shippers are happy about it."

Vise predicts that truckload rates in 2023 will be "sticky" because of limitations on truck-building capacity. "We're not producing as many trucks as we need. But that's slowly getting better."

Top carrier executives agreed with Vise's assessment. However, they warn shippers to prepare for mid- to single-digit contractual rate increases in 2023 due to inflation's



relentless push on virtually every aspect of a truckload carrier's operation.

"We're continuing to see it every month from our vendors, suppliers, OEM's [original equipment manufacturers], everybody," says Greg Orr, president of CFI, which recently was sold to Heartland Express for $525 million to create the eight-largest TL carrier in the country. "I don't see inflation slowing down any time soon."

At the same time, truck analysts say that they're seeing positive signs in the full-truckload market, which has been buffeted by mergers and acquisitions—especially in the second half of this year.

Vise says the TL market has "hit an inflection point," meaning freight volumes will grow slightly next year and capacity usage will bottom out above the 10-year average. "But this forecast doesn't presume an economic recession, so downside risks are substantial," he warns.

With that in mind, let's take a deep dive into factors affecting the truckload market—by far the largest sector of the $830 billion trucking industry.

Capacity equations

In a perfect world, there are exactly the right number of trucks deployed around the nation to haul exactly the right amount of freight at the proper price levels so that both shippers and carriers are happy.

Ideally, yes. In reality, this is never the case. Especially in the post-pandemic era, where truckload capacity

has been unevenly matched with freight levels. At first, during the economic shutdown in the spring of 2020, there was way too much capacity.

Then came an unexpected surge in demand for some supplies, leaving truck capacity buffeted and scrambling to meet demand amid crowded ports and freight piling up due to lack of drivers.

"Capacity is a lot looser than it was six months ago," says CFI's Orr. "We're not turning down thousands of loads each week as we were early in 2022." However, he says that the unevenness in demand among various sectors—both retail and industrial—has made it nearly impossible to predict freight demand levels with any degree of confidence.

"The weird thing is, it's not consistent," says Orr. "There may be a pocket in, say, the Pacific Northwest last week, but not this week. It just seems to be hit and miss every week." He and others in the TL sector say that this is a holdover from the COVID era. For example, many shippers ordered product a year ago that's still flowing through the supply chain.

"The unbridled chaos we've been dealing with for almost three years is moderating," says Mark Rourke, CEO and president of Schneider. Green Bay, Wisc.-based carrier operates the fifth-largest truckload operation and is a huge intermodal operator in North America.

After softening a bit in mid-year, 2022 freight volumes generally settled to levels seen in July 2020 and 2019, according to Ken Adamo, chief of analytics for DAT, a trucking information services firm. "After several years of volatility, truckload volumes for van and reefer freight followed a more typical summertime pattern," he says.

"I think we're getting closer to normal," says Orr. "China is our largest importer and it just started opening up the pipeline. So, we're getting imports back to where it used to be."

Some North American manufacturers, tired of endless supply chain delays and outrageous trans-Pacific maritime rates during the pandemic, are moving plants closer to home in a phenomenon known as "in-shoring" or "nearshoring." Whatever it's called, it's good for large TL carriers in and out of Mexico. CFI gets more than one-third of its revenue in and out of Mexico.

"There's a lot more freight down there than we have capacity," adds Orr. "We could do double the amount of volume northbound out of Mexico if I had the ability southbound to get it. They're begging us to take more, but I don't have the return loads southbound."

M&A market is hot

After a couple of quiet years, the mergers and acquisitions market in the truckload sector perked up in the second half of 2022.

By far, the largest acquisition was North Liberty, Iowa-based Heartland Express's purchase of Contract Freighters Inc.'s (CFI) non-dedicated U.S. dry van and temperature-controlled TL business and its CFI Logistica operations in Mexico from Montreal-based TFI International, Inc. for $525 million.

It was one of the largest truckload acquisitions in the full-truckload market in this century, even without CFI's dedicated and logistics U.S. brokerage operations, which were not included in the deal. It makes Heartland Express the eighth-largest TL operator in the country with 2022 revenue expected to top $1.3 billion.

"It's been great," CFI's Orr says of new ownership. "We loved being part of TFI, and it was great for us. But Heartland's purchase has allowed us to be entrepreneurial. We're owned by a company that is similar to us."

The attraction of low-cost, non-union operators such as CFI has drawn others to make their acquisitions in the TL market. Besides Heartland buying CFI,

Fort Smith, Ark.-based USA Truck was bought by DB Schenker, the German logistics giant, for $425 million in an all-cash deal last summer.

USA Truck will bolster DB Schenker's freight presence in the United States. The truckload company has approximately 2,100 employees with a fleet of 1,900 trucks. The carrier also has a strategic network of terminals across the Eastern half of the United States.

Among other TL acquisitions through June and July alone were KLLM Transport Services' acquisition of Quest Global; P.A.M. bought Metropolitan Trucking; and up north, Fastfrate acquired Challenger Motor Freight in a major Canadian acquisition.

Before its CFI acquisition, Heartland Express picked up Roaring Spring, Pa.-based Smith Transport. And Schneider, in its second acquisition of the year, bought deBoer Transportation, a regional and dedicated carrier headquartered in Blenker, Wis.

But not everyone is growing or being acquired. U.S. Xpress Enterprises (USX), the ninth-largest TL carrier, announced a corporate restructuring. It expects to improve its over-the-road (OTR) operations and generate $25 million in annual cost savings beginning in fourth quarter of 2022. Most of the savings, an estimated $20 million, will come from previously announced layoffs, the company said.

After finding "certain successes" in its vision of building a digitally enabled OTR fleet, U.S. Xpress wants "to right-size its cost structure" in what it views as a softening freight market, president and CEO Eric Fuller said in a statement. The company plans less than $100 million in capital expenditures in 2023 after spending $150 million this year.

FTR's Vise says that shippers will be marginally happy and carriers marginally less happy with their 2023 rate negotiations with truckload carriers. His forecast for 2023 TL contract rates will be about 4% lower overall in all segments, compared with a 14% drop in spot market TL rates next year.

U.S. Xpress wants more contract business after finding itself overly exposed to the spot market, which has faced softening demand and plummeting rates in recent months. The high cost of diesel is a factor at U.S. Xpress because the company has been forced to take on more in fuel costs as fuel surcharges aren't applied to the spot market.

A terminated lease for a property in Atlanta will also save U.S. Xpress $2 million per year, CFO Eric Peterson said. And the carrier will cut costs by running its tractors 100,000 more miles annually beginning in 2023. That will raise the average age of its trucks from 22 months to 27 months.

Rates, rates, rates

Truckload shippers could be getting some breaks in their 2023 contract rates. However, analysts and carrier executives say that it's not the same for everybody, and it varies greatly by lanes, city pairs, and industry and retail segments.

FTR's Vise says that shippers will be marginally happy and carriers marginally less happy with their 2023 rate negotiations with truckload carriers. His forecast for 2023 TL contract rates will be about 4% lower overall in all segments, compared with a 14% drop in spot market TL rates next year. "We're still going to have spot rates bottoming out above 2019 levels," he says. "It's still a reasonably healthy spot market."

At CFI, 93% of freight moves under contract. Orr says he recently closed a deal with a shipper who's among CFI's five largest customers for a 7% rate increase in 2023. "I think they understood the reasons for it," he says. "While they didn't like it, getting that commitment to capacity is extremely important to them. We're trying not to play the feast or famine game, and we're not trying to take advantage of the situation."

Schneider CEO Rourke says that actions to enlarge the carrier's over-the-road fleet are nearly impossible. Besides a shortage of qualified drivers, Class 8 2023 model tractors are being allocated tightly by OEMs. "There's absolutely no relief, and that puts constraints on the industry," he says. "That's one very much negating feature, along with inflationary pressures that come with that."

Rourke says Schneider would buy 20% more new trucks—if they were available. As it is, Schneider has 11,650 company drivers, 10,120 company trucks and 33,830 trailers. "It's a bit of a game of Whack-a-Mole," he adds.

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A SPECIAL SUPPLEMENT TO:
SUPPLY CHAIN MANAGEMENT REVIEW

SUPPLY CHAIN DESIGN MEETS THE RESHORING TREND

Companies are rethinking globalization and repositioning more of their operations and sourcing closer to home. Here's how the trend is affecting supply chain design.

BY BRIDGET McCREA, EDITOR AT LARGE

With globalization no longer the default option for all companies, many are returning product manufacturing from foreign countries to their home countries (reshoring); transferring work to different organizations within their own regions (nearshoring); and relocating business processes from one country to another (onshoring).

Mexico has become a particularly attractive target for U.S. firms. In November, the country's Economy Minister, Raquel Buenrostro, announced that 400 different companies were currently seeking nearshoring opportunities in the country. She credited the U.S.-Mexico-Canada Agreement (USCMA) and Mexico's close proximity to the United States with driving some of that momentum.

Regardless of which repositioning approach a company takes—reshoring, nearshoring, onshoring, or a hybrid—the general push to get manufacturing and sourcing closer to home is on. In fact, one recent Deloitte study uncovered "increased interest in moving manufacturing closer to the end consumer to mitigate disruption risk and the inflationary impact on the cost of goods." In total, American companies reshored about 350,000 jobs in 2022, the company says, compared to 260,000 the prior year.

In the United States, CEOs have been vocalizing their reshoring goals on their earnings calls. During the fourth quarter of 2022, for example, there were 122% more mentions of reshoring than there were during the previous quarter. Fortna's Darren Jorgenson says it's a topic he's also hearing more of these days. "Reshoring is something that comes up every time we work on a project and design a supply chain," says Jorgenson, practice leader of the strategy team. "We're seeing some instances where manufacturing is moving into Mexico, which is a solid business choice for some companies."

Rosemary Coates, executive director of the Reshoring Institute and president of Blue Silk Consulting, says many companies have already taken the interim step by seeking out more U.S. suppliers to add to their supply chains. "In the past, sending a buyer to China or sourcing products on sites like Alibaba kind of just happened automatically," says Coates. "Now, more companies are trying to source materials domestically and are very interested in reducing risk in their supply chains."

Coates says some of these moves are being driven by all of the misery that companies endured during the pandemic as they tried to get goods out of China. "There is a bigger recognition of the related supply chain risks," says Coates, "and to mitigate that, companies are redeveloping sources back in America. That is the interim step."

Other organizations are going a step further and either bringing manufacturing back to the United States or making decisions to not produce goods overseas anymore. "There's no question in my mind that this is happening right now at a slow and steady pace," says Coates.

Slow and steady pace

In most cases, Coates says a company's decision to reshore, nearshore or onshore happens at the executive level and is seen as a "much more strategic decision" than it ever was in the past. This aligns with a bigger shift in the way organizations think about their global supply chains and the strategies associated with these interdependent networks.

"There's a whole shift in the way companies are thinking about their global supply chains and the related strategies," says Coates. For example, she says more of them are considering moving operations to Mexico, where labor rates are now lower than they are in China, according to a recent Reshoring Institute global labor study across 12 different countries. India and Vietnam are two other low labor-cost countries that companies may want to consider.

"Mexico is always a good choice due to its close proximity to the United States. You don't have to wait for an ocean container to be unloaded at a busy U.S. port," says Coates. "Instead, you can just drive across the border." As an added bonus, the USMCA allows much of the merchandise produced in Mexico to be brought into the United States duty-free.

Of course, once the decision is made to change manufacturing locations, then the rest of the supply chain has to "fall in line," says Coates. The shifts include—but are not limited to—changing supply chain and logistics partners as well as possibly locations. You also have to manage a change in the routes and flows of your supply chain. For example, instead of bringing materials in via airfreight from Shanghai, you may be transporting truckloads of goods across the Mexican border.

The people component also comes into play here. "These shifts require different supply chain skill sets, which means the professionals who run these networks have to be open to changing the way they think about supply chain management," Coates points out. "They may also have to up their skill levels and think more openly and creatively about how to deliver on their job requirements."

All aboard the reshoring bandwagon

The global pandemic, trade wars, tariffs and ongoing supply chain disruptions are just some of the reasons why global management consultancy Kearney says American companies are getting more serious about reshoring. Kearney also says reshoring is being redefined as "more companies pursue the best cost instead of the lowest cost and weigh cost against other factors such as supply chain resiliency and sustainability."

Jorgenson sees evidence of this firsthand when he works with companies that want to build supply chains that are as sustainable as they are resilient. "Nearshoring can provide benefits in the form of resilience and reliability, and particularly when it comes to managing disruption," says Jorgenson, who sees more companies wanting to get closer to their customers and minimize any geographical gaps caused by globalization.

Lisa Henriott, senior VP of product marketing at Logility, is also seeing more reshoring as a way to get operations—both manufacturing and distribution—closer to the end customer. Companies are looking at the trade-offs, knowing that one set of costs may go up (e.g., labor costs) while another goes down (transportation) as a result of the supply chain shifts. Companies also have to consider the taxes, tariffs and other costs associated with reshoring, understanding that truck versus rail versus parcel all have different cost structures and delivery speeds.

Due to the uncertainty in the current marketplace, some of Logility's customers are also using data to assess variables like weather conditions, demographic trends and housing markets in specific geographic regions. This, in turn, can help them determine the viability of onshoring, nearshoring or reshoring their operations. "Companies can use causal factors to influence their forecasts," she explains, "as yet one more way to do some fairly advanced demand planning."

Closing the loop

Regardless of whether companies maintain their global supply chains, onshore all of their operations or use a hybrid approach—some onshore, some offshore—they all want anti-fragile networks that are resilient, sturdy and able to stand up to disruptions brought on by events like the COVID-19 pandemic.

To achieve this goal, many companies lean on technology that helps them sense problems, forecast demand and drive risk out of their supply chains. They're also developing tighter bonds with their customers, suppliers and other business partners in an attempt to "close the loop" that may exist between them. This, in turn, helps drive higher levels of collaboration and connectivity in any business condition.

"Creating closed-loop networks helps you manage your inventory effectively while also being able to anticipate future disruptions," says Philip Vervloesem, senior VP at OMP USA. "Anti-fragile networks go a step further by focusing on building the right level of buffers that ensure that you can cope with any type of supply or demand disruptions."

Knowing that it takes a village to make a single global supply chain tick, Vervloesem also tells companies to focus harder on the collaboration and connectivity across those various entities when redesigning a supply chain. This advice applies to any supply chain, be it global, domestic or both. "Having a closed loop with your co-manufacturers, customers and all suppliers' tiers is extremely important," says Vervloesem, "because you can shift gears much faster when everyone is in that closed loop versus working in their own silos."

Making the shift

As companies assess their supply chain operations and decide whether to take interim steps like sourcing more goods onshore, or larger steps that involve the full repositioning of operations to countries like Mexico, these organizations will also be redesigning their networks to accommodate the shifts.

Jorgenson reminds companies to view reshoring as a process versus just a step, and to ensure that any changes made align with the company's overall mission. Be prepared to tackle some complexities, he adds, and focus on good organizational alignment and change management as you work through it. "Then during the actual transition," Jorgenson adds, "make sure you have the redundancies in place to ensure that there are no issues as you make the shift."

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