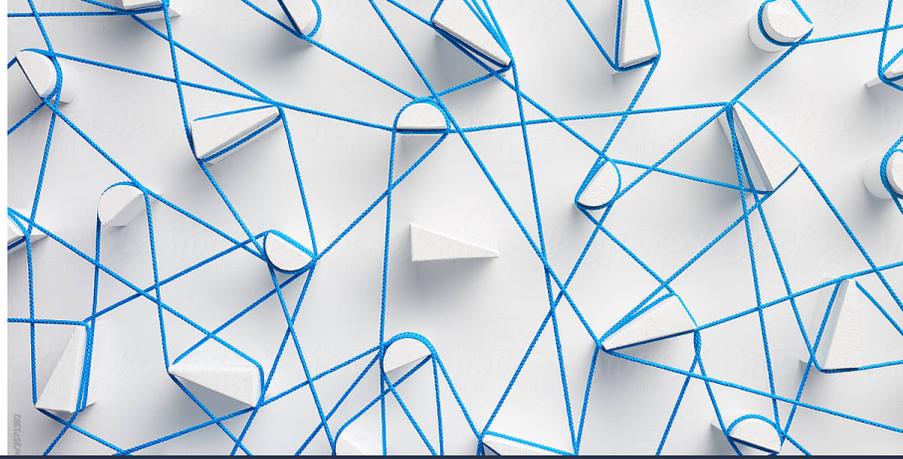




LYNN CULLOTTA



A Supply Chain in Transition

Carl Cullotta

The events of the last year have put supply chains under scrutiny like never before. A “perfect storm,” combining the global pandemic, societal changes and unrest, and weather/environmental issues, created massive and sustained disruptions in supply chains. Based on its complexity (i.e., across the types of projects, geographies, scope of products, number of entities involved, etc.) no industry felt the disruptions more than the construction industry.

At first look, it is easy to attribute the supply chain disruptions to COVID-19. However, upon deeper analysis, COVID-19 did not *create* supply chain challenges. Rather, it accelerated and heightened the impact. And, most importantly, it *exposed* many of the weaknesses of the construction industry supply chain.

Exacerbating the problem is that the root causes of supply chain disruption go well beyond the construction industry...making it highly unlikely that the industry can sidestep these challenges. A successful approach will most likely acknowledge the challenges, monitor developments, and employ strategies to best navigate change and mitigate risk.

This paper examines today's construction industry supply chain including the key components and linkages. We examine some of the challenges that exist and five critical root causes that are driving them. Finally, we project the challenges over the next decade and identify potential “risk mitigation” strategies industry participants may employ.

A typical commercial construction project, whether a new building or major renovation, represents one of the most complex processes found in commerce today. Most large projects take months, if not years, from design and project specification through actual construction. Over this time, there could be hundreds of entities involved, most of which can have significant bearing on whether the project is completed on time, on budget, and to performance targets.

The overall construction project consists of two broad workstreams. One is the design and development workstream led by owner/developers, architects and engineers. This workstream defines the *where, what, when and how* about the project. The second is the product flow workstream that, when implemented properly, fulfills the expectations of design and development.



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The Construction Industry Supply Chain

While the product flow workstream (the supply chain) is complex, it can be organized against four major components--raw material suppliers, finished goods, transportation, and distributor/installer (often referred to as the "last mile").



Raw Materials -- Raw material needs are defined by the finished goods "formulation." This dictates the required ingredients and the degree of flexibility, (e.g., number of suppliers, specification tolerance, acceptable alternative materials, etc.), the manufacturer has for each finished good. Raw materials can impact the short- and long-term supply chain based on immediate availability as well as the level of reserves available to supply future demand. In many product categories, the supply chain includes domestic and global sources, which serves to add complexity to transportation. Finally, raw materials have a significant bearing on supply chain economics as they often represent up to 70% of the cost of the finished goods.

Finished Goods -- The effectiveness and economics of the supply are impacted by a range of issues related to finished goods manufacturing. Total industry capacity (and ability to ramp up) have been defining factors contributing to recent supply chain shortages. The industry structure, or "manufacturing footprint" (i.e., number of manufacturing facilities, average plant output, location of these facilities) influences cost and resiliency. And this manufacturing footprint has a significant impact on the carbon footprint of the supply chain.

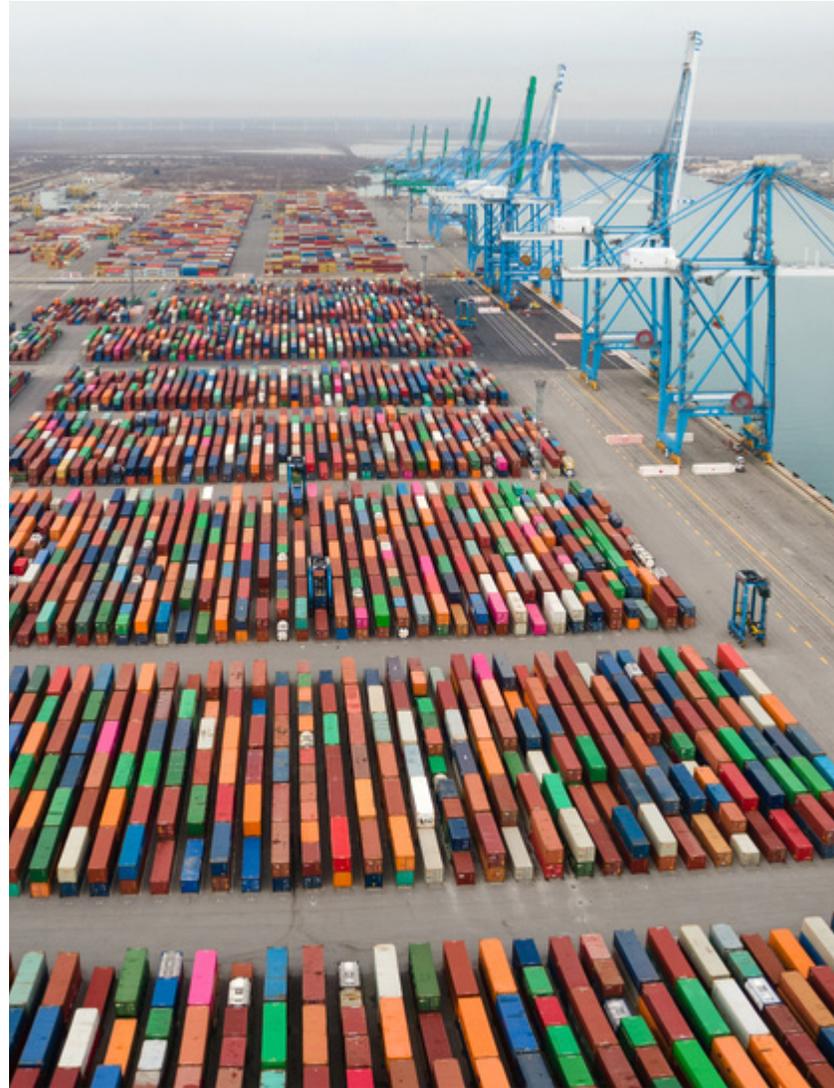
Transportation -- Transportation addresses the movement of raw materials to the manufacturing plant as well as the movement of finished goods to the "last mile." Including all modes (e.g., air, sea, rail, long-haul trucking), this sector has undergone dramatic change in the last 20-30 years. Data from the Department of Transportation suggest that logistics science and information technology have contributed to businesses' logistics cost reductions of over 20%, while expanding the range of options available to the finished goods manufacturer.

Distributor and Installer -- This final step in the supply chain is also the most fragmented. This "last mile" component includes product delivery to the jobsite as well as installation. The participants include thousands of small, largely independent, product-specific trade contractors served by large networks of specialty distributors.



Product Flow Workstream

Historically, few finished goods suppliers viewed the supply chain holistically. Often, internal silos (i.e., purchasing, operations, logistics, sales & marketing) only had a view to their step in the chain--and perhaps an adjacent step. This approach created weaknesses, many of which have been exposed in the last year. For example, changes in the installer (contractor) labor pool are occurring in many product segments. Fewer employees are available, and the relative skills/capabilities are declining as industry veterans leave the workforce. This factor could be a powerful input to finished goods manufacturers' decisions around what is produced, how it is delivered and installed--effectively impacting all components of the supply chain. A silo approach to supply chain management makes it difficult for the finished goods manufacturer to effectively implement these changes.

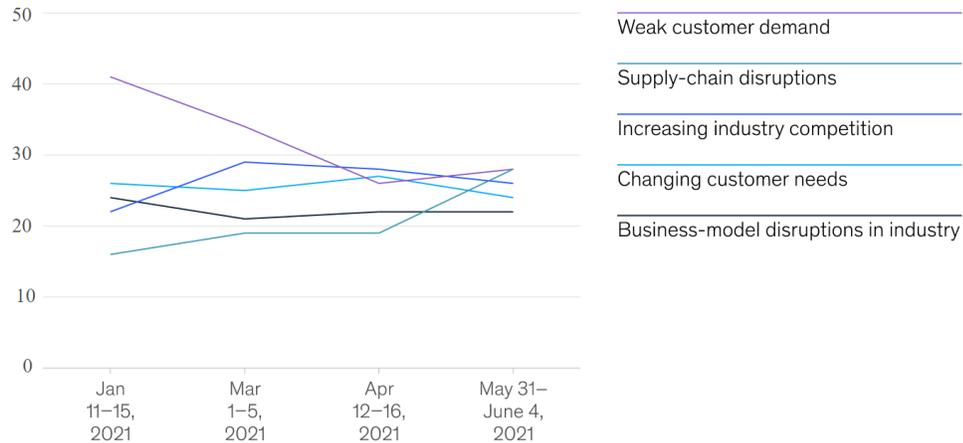


Supply Chain Poses the Greatest Risk to Growth

A recent survey by McKinsey & Company highlights the level of concern that supply chain disruption risen to in U.S. business. It is now perceived as the greatest risk to growth for businesses.

Respondents cite supply-chain disruptions as a top risk to their companies' growth and a more acute concern than before.

Potential risks to companies' growth, next 12 months,¹ % of respondents



¹Out of 15 risks that were presented as answer choices; question was asked only of respondents in private-sector companies. Jan 2021, n = 913; Mar 2021, n = 916; April 2021, n = 1,085; June 2021, n = 928.

McKinsey
& Company

But the supply chain is not the whole story.

Real estate developers' business decisions are defined by several key issues:

- **What to build** will be defined by internal business strategies, HR considerations, company cultures and, of course, sustainability
- **Where to build** will be driven in part by demographics, employment shifts, and the need to compete for the qualified employee pool
- **When to build** will be influenced in part by changes in the overall new construction or renovation project cycle brought about by the industry's new capabilities and constraints
- **How to build** will be shaped in part by codes, sustainability, and materials availability / efficacy

Supply chain concerns are, of course, not the sole driving factor influencing these issues. But supply chain considerations will contribute to decisions related to each of the questions real estate developers are asking themselves.

The most responsible finished goods supplier partners will go beyond "price and availability." These supplier partners will provide market insight in a timely manner to help inform the developer's real estate decisions about:

- Looming raw materials changes and associated changes in finished goods
- Potential short- and long-term transportation issues
- The distribution and installer structure that define "the last mile"



Unending Set of Issues Impacting Supply Chain

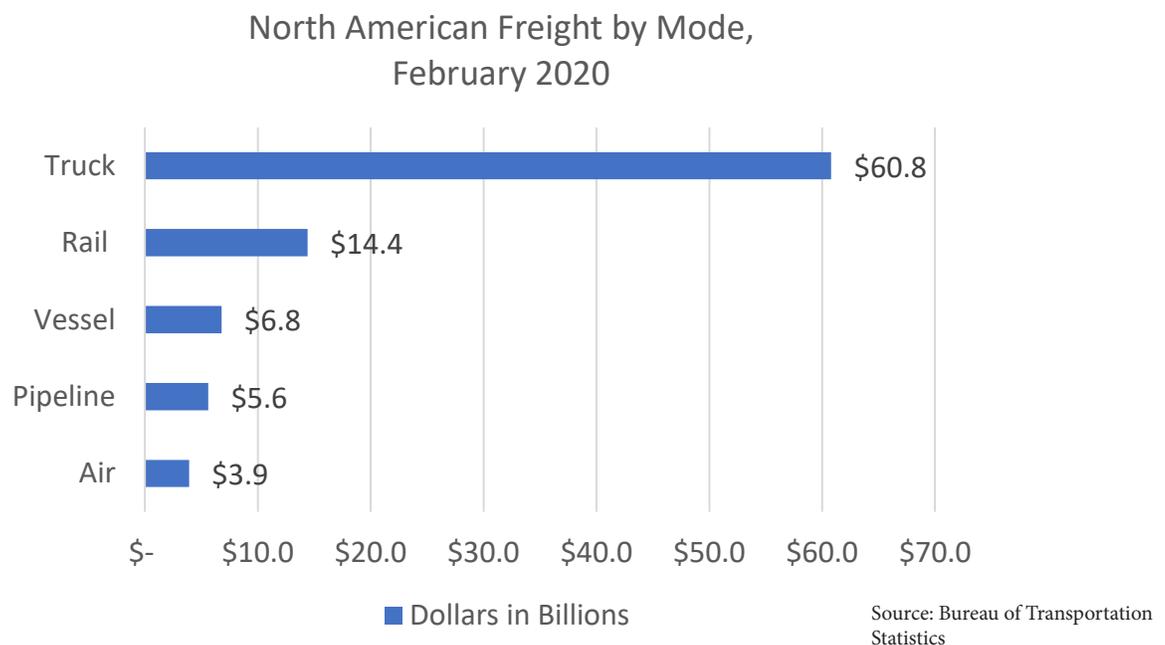
Looking back at the last year, there is a seemingly unending list of discrete issues that have contributed to supply chain breakdowns. Many of these were underlying issues / trends that have been evolving for years. The discontinuity created by COVID-19 exposed them. Supply chains are now in the public conversation--either as examples of the "COVID-19 hangover" that shall pass, or long-term concerns. Let's examine some of the most visible and important issues that are creating disruption in the construction industry supply chain:

- **Gasoline availability / costs.** The Texas winter weather and the recent pipeline cyber attack have demonstrated how tenuous gasoline availability and low prices are likely to be going forward
- **Steel supply / cost.** The Worldsteel Organization and World Bank documents indicate that China now produces half the world's steel. Supply and cost will be at risk with any significant change in global politics and / or government policies
- **Manufacturing locations.** To achieve carbon neutrality, many companies will be forced to rethink their manufacturing footprint, along with where and how they source raw materials
- **"Aging out" of the workforce.** With the median age of the factory and construction worker in the U.S. several years older than the workforce overall, there is a looming threat of workforce reductions through retirement. The latest U.S. Census and projections by the Bureau of Labor Statistics project a "silver tsunami" of retirements over the next 10 years. This will take not only productive employees, but also a significant body of knowledge, out of the workforce. Innovation to boost employee productivity and / or more effectively compete for employees to replace these retirees will be necessary to keep the supply chain intact.



Transportation will be a Constraint for a Decade

- **Rail infrastructure.** Data assembled by the U.S. Department of Transportation indicates that rail represents ~1/5th of domestic shipping today. Railroad execs surveyed in 2019 do not believe that rail can take more than a few points of share without significant upgrades to an aging infrastructure. They have little expectation that this investment is coming from the government--nor do they expect that incentives will be provided for the cash-strapped industry to invest in the required upgrades. Highlighting the need for infrastructure upgrade is the fact that the rate of derailments is already at historic highs. Without infrastructure upgrades, it is unlikely that rail can shoulder much more of the transportation burden.

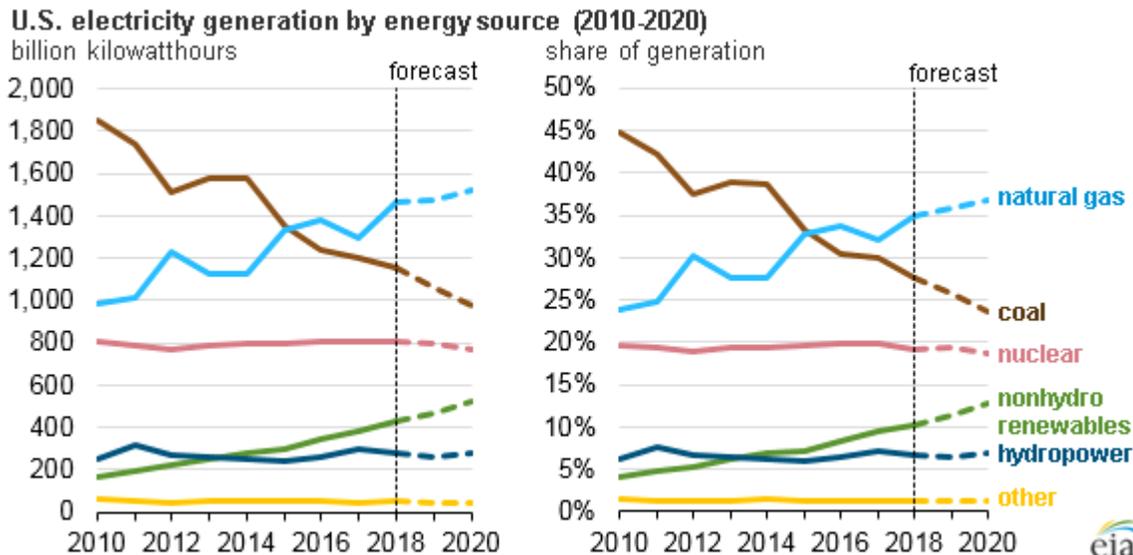


- **Road infrastructure.** A limiting factor on the efficiency / effectiveness of the trucking industry is the state of the nation's highways and bridges. The American Society of Civil Engineers' annual report card estimates that over 40% of the nation's bridges and 20% of the nation's roads need repair. Assuming the public funding is available, the timeframe to upgrade road infrastructure (based on lengthy construction cycles) will still make this a transportation constraint for the next decade



And Then There's Power...

- **Power Grid and Infrastructure.** Perhaps no component of infrastructure in the U.S. is more at risk than electricity. The Department of Energy's Energy Information Administration tracks electricity generation and consumption. Current generation capacity only exceeds demand by ~3% (in the best of conditions). Without any buffer capacity, brownouts / blackouts are becoming routine at peak use times



Almost all sources of electricity are under fire:

- Nuclear faces negative public safety perception and stringent regulatory challenges. And even if these are overcome, the construction cycle for a nuclear power plant is still well over 5 years
- Coal is inevitably facing a phase out due to impact on the environment. In fact, over 500 coal fired units have been closed in the last decade, with 60 more expected to close by 2025
- Natural gas is a cleaner alternative than coal--about half the CO2 emissions for equivalent electricity produced. As a result, natural gas has increased its share of generation capacity, largely at the expense of coal, over the last two decades. However, this fossil fuel will come under increasing pressure as the world gets closer to its emissions goals. Carbon neutrality will be difficult to achieve without a transition from natural gas electricity generation to greener alternatives
- Renewable energy is considered the long-term solution. However, approximately one-third of electricity from renewable sources is hydroelectric power. Severe drought (and forecasts for extended drought) put hydroelectric power output at risk



Shortages are Strongly Affecting Transportation

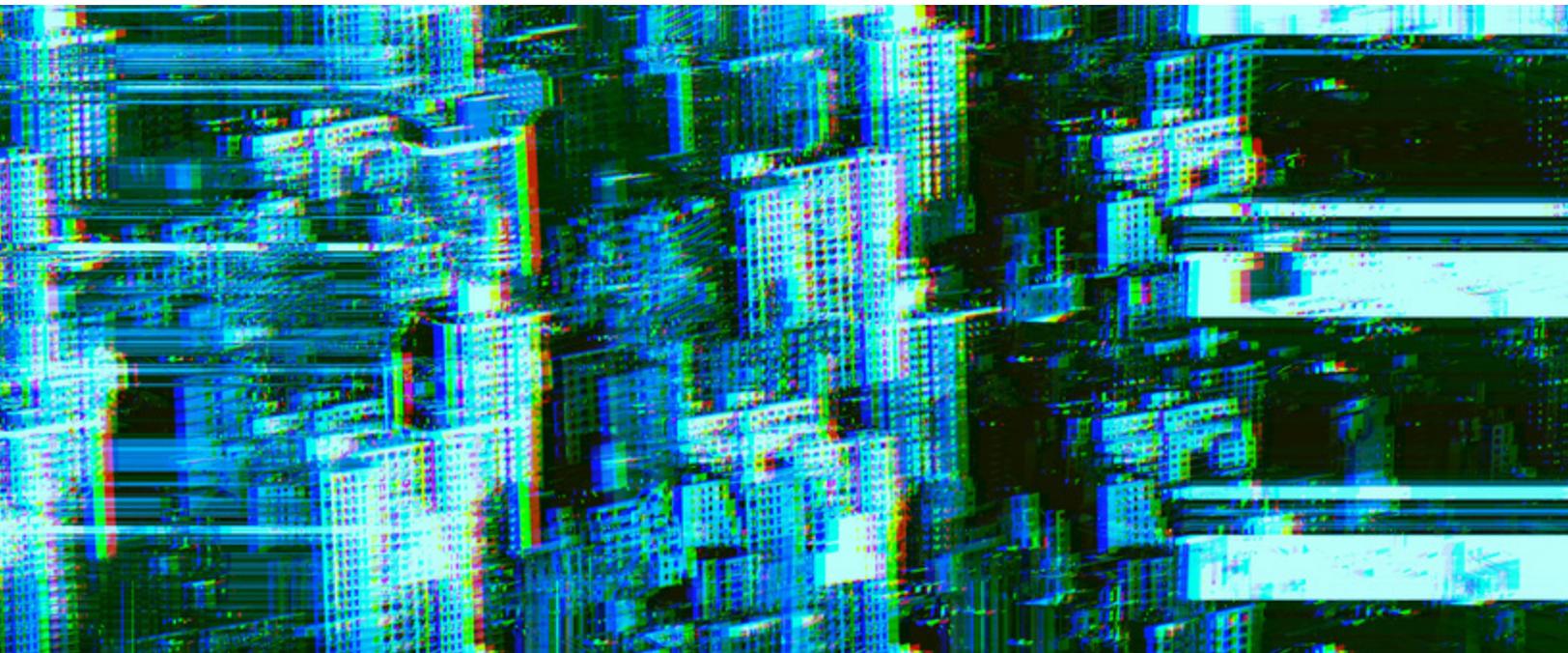
As the industry transitions from fossil fuels and builds the necessary capacity from renewable sources, it is inevitable that supply and reliability of electricity will be at risk for the foreseeable future.

- **Shortage of truck drivers.** The shortage of truck drivers in the U.S., (particularly long haul), has become acute. The American Trucking Association estimates the shortfall this year is approaching 100K and will exceed 160K by 2028. Finished goods suppliers often report their daily truckload shipment volume down by as much as 20% due to lack of available drivers. The driver shortage has been building since 2014--with no clear solution in sight.
 - *Self driving trucks are not expected to provide relief for the driver shortage before 2030*
 - *Growth in shipping will exacerbate the shortages*
 - *Long-haul trucking industry has high turnover rates, creating a need for over 50K drivers annually just to replace those leaving the industry*
 - *The value proposition (e.g., compensation, work / life balance) is not competitive with other industries / lines of work to attract would be drivers*
- **Shipping container shortages.** According to data aggregated from several sources by Statista, there are an estimated 160M+ shipping containers globally. These containers are designed for inter-modal transport and are responsible for over 90% of the world's transport. While it is expected to recede, the industry is currently managing through a container shortage of over 10% due to a range of factors.
 - *Slowdowns in ports due to social distancing work regulations have left more containers "on the water"*
 - *Trade and shipping imbalances, as countries emerge from COVID-19 at different rates, have left more containers stranded in the wrong places*
 - *Slowdown in new container manufacturing happened during the pandemic*



Fragmentation of Trades Offset Innovation

- **“Last mile” logistics.** Last mile logistics includes the local distributor and local trade contractor. In many respects, the distributor has become the most stable step in the construction industry supply chain. Consolidation within specialty categories (e.g., roofing, plumbing, electrical, etc.) has created large, well-capitalized, national networks. These businesses have aggressively invested in digital technologies to enhance operations, inventory management and logistics. These distributors have also invested in product, capabilities, and equipment to increase their value to and strengthen their relationships with the trade contractor. Finally, many distributors of scale have expanded their supplier relationships to mitigate any supply risk at the local level
- **Installers.** The installer segment is characterized by fragmentation, with each trade consisting of thousands of small, single location businesses. However, due to scope and duration of the job, expertise, bonding considerations, etc., there is a subset of typically larger contractors in each trade who focus on the commercial market. While labor challenges overall are making it difficult for contractors to field crews and meet project deadlines, the larger commercial contractors are least affected due to the security, compensation and benefits they can offer relative to their smaller competitors
- **Building design changes.** As employers respond to sustainability needs and new work environments that are an outgrowth of COVID, the next decade is expected to see the pace of innovation in building design increase. New designs will demand that supply chains are flexible and resilient to evolve with changes in product demands and potential revamping of some construction processes



The “Tie Goes to Residential”

- **Residential construction demand.** One of the challenges the commercial builder encounters for many product categories is the relative size of the commercial vs. residential markets. This often forces the product manufacturer to consider product allocation decisions. The combination of larger market size and dominant players (e.g., large national residential builders, large channel partners like Home Depot) often means that the “tie goes to residential.” Residential housing starts are running at historically high rates. Freddie Mac’s latest analysis of the state of the U.S. housing market estimates a shortage of up to 6M single family housing units in the U.S. The robust pace of construction can be expected to continue through the middle of the decade. This will likely cause periodic disruptions in the commercial construction supply chain as product suppliers react to residential demand.
 - **Trade and tariffs.** Trade and tariff policies are largely an unknown in evaluating supply chain impact. While most construction product manufacturing is domestic, many finished goods suppliers are heavily reliant on international sources of raw materials. Any indication of political changes, continued movement toward nationalism, or trade and tariff wars are likely to have immediate ripple effects on product costs--and potentially supply
- **Workplace regulations.** A government policy area that may have greater immediate impact on supply chains is workplace regulation. For example, the definition of a safe work environment, to include social distancing, has slowed plant production in many labor-intensive industries. Jobsite construction has lengthened projects 50% or more due to limitations on the number of trades (and size of crew) allowed on the jobsite. General contractors expect the longer project durations will continue into the second half of the decade, and will require more project management time to deal with unforeseen disruptions



Right People, Right Skills, Right Cost

- **Employee availability.** Employee availability is likely to be one of the most severe and longest lasting challenges facing the construction industry, with impacts at all stages of the supply chain. Surveys conducted by the National Association of Home Builders indicate that builders expect labor availability to be the number one business challenge over the next decade. The combination of an aging workforce leaving the industry and an inability to attract young workers will result in a sustained employment deficit. While the industry has navigated through a labor shortage that began after the last housing crisis, the combination of market demand and growing labor shortages will likely mean longer construction times, more disruptions, and substantially higher labor costs over the next decade
- **Employee skills and training.** An equally challenging Human Resources issue will be employee capabilities. Veterans are leaving the workforce (and taking their institutional knowledge with them.) Fewer trade school graduates and reduced union membership has created a shortage of skilled apprentices. This shortage of skilled workers has spread across manufacturing and construction. Some industry estimates put the projected shortfall in these segments at over 3M workers by 2030
- **Labor costs.** The growing shortage of skilled workers will all but assure that labor costs will continue to rise. Construction project economics will change--general contractors and specialty trade contractors will focus more on product price to remain competitive on bids, since they have less latitude with margins on their labor costs. And product manufacturers will be faced with higher direct manufacturing costs in a market much more sensitive to the price of their product



What About COVID?

COVID-19 has often been called a scapegoat over the last year. As one of the defining events of this century, it has been easy to attribute any challenge without an easy answer to the “COVID-19 effect” or the “COVID hangover.”

There is no doubt that COVID-19 impacted society in severe and lasting ways. Individuals work differently than they did in February 2020. There are population shifts to smaller markets that are likely to continue for the next several years. The U.S. healthcare system in 5-10 years may not be recognizable compared to today’s system, largely as a result of the exposure of shortcomings and learnings from the pandemic response.

For supply chains, however, COVID-19 more likely served as “the canary in the coal mine.” There is clear evidence that most of the root causes introduced earlier were already in motion. The pandemic exposed these trends, and more importantly, many of the impacts. Each of these is worth a “deeper dive.”

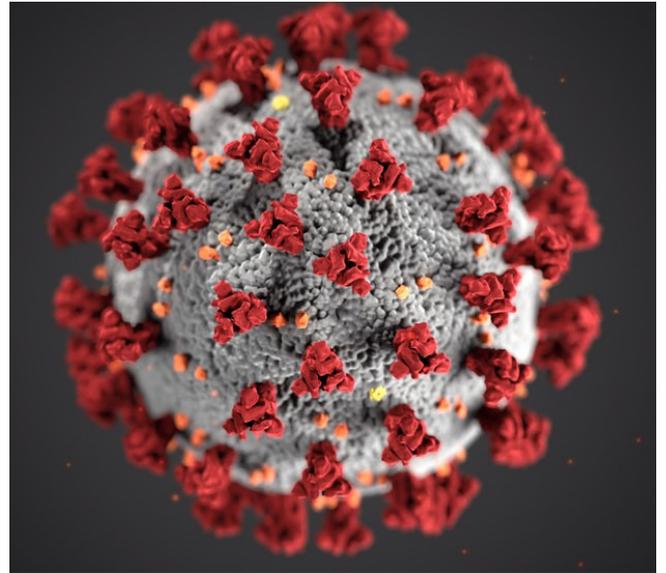


Photo by CDC on Unsplash



Root Causes of Change

We examined 17 discrete issues that are impacting the industry supply chain today and are expected to do so over the next decade. (And this list may well be just scratching the surface!)

Effectively managing the supply chain through the lens of so many issues is not feasible. However, all these discrete issues can be traced to five root causes. These root causes dictate the frequency, duration, and severity of each issue examined. Monitoring (and planning for) the changes in these root causes is likely to provide greater (and earlier) visibility to emerging supply chain challenges, and ultimately, more effective risk mitigation strategies.

We expect these defining themes (or root causes) will drive most of the significant changes in supply chains (and, in fact, commerce overall) over the next 10 years.

5 Themes

1. Environment
2. Labor
3. Security / Cybersecurity
4. Technology
5. Government

1. *Environment* is the most compelling. With the mounting evidence of both causes and effects of climate change, the move toward carbon neutrality will supersede all other business decisions and government policies

2. *Labor* is the most immediate challenge. The aging of the workforce (coupled with declining populations) in most developed countries are facts. This will require new and innovative ways to recruit and retain employees, a dynamic even more challenging in manufacturing and distribution

3. *Security/Cybersecurity* has come to be considered a cost of doing business in the digital age. It will require a different way to look at supply chains—often introducing redundancy and flexibility that will outweigh efficiency

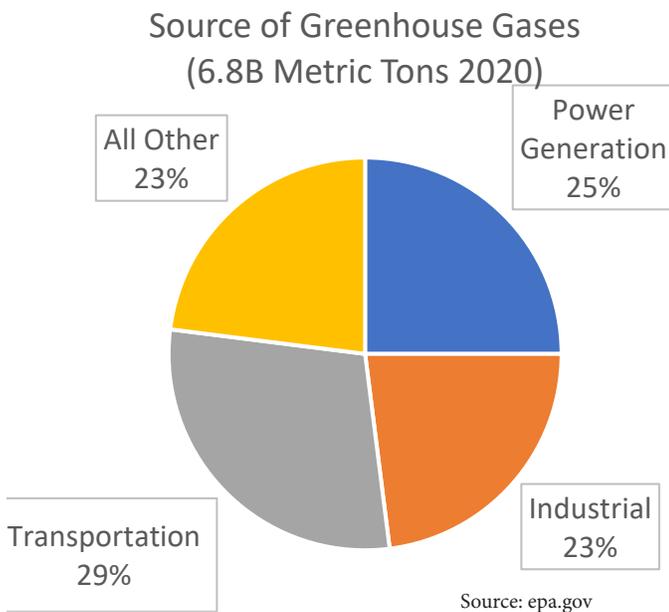
4. *Technology innovation* continues to accelerate. However, the timeframe of adoption is still quite lengthy—often with unintended consequences for the supply chain along the way

5. *Government* will be a wild card based on domestic/global politics, priorities, and needs. And changes in government policies and regulations could serve as a catalyst or serve to temper the degree and pace of change we will see in the supply chain



Environment and Climate Change

Achieving carbon neutrality is the most compelling global mandate for the next 30 years. This issue is likely to supersede any other issues in government policy and industry investment—with some compelling implications for the construction industry supply chain.



The Facts

The global goal is to achieve average global temperatures that do not rise more than 1.5 degrees (C) above pre-industrial averages.

Evidence of the impact of climate change is adding up. For example, in 2019 alone there were 15 extreme weather events worldwide, a number that is increasing annually (NOAA analysis). Each had some level of societal impact and industry disruption.

The U.S. Environmental Protection Agency projects that achieving the global temperature goal will require ~6% annual reductions in greenhouse gas emissions over at least the next decade.

Most multi-national corporations have committed to carbon neutrality by 2050 as tracked by the climatepledge.org.

There are limited sources of greenhouse gas emissions to target if meaningful annual reductions are to be achieved—power generation, industrial, and transportation applications represent >75% of all greenhouse gas emissions. And fossil fuels are directly linked to over 60% of all greenhouse gas emissions. No reasonable strategy to address climate change can occur without addressing these four factors.



Environment and Climate Change--The IMPACTS

Power availability is likely to be the first fallout from addressing climate change. Only ~30% of global power generation capacity is from renewable sources today, while >60% is generated from fossil fuels. A study by industry research group Wood Mackenzie estimates the cost to convert the U.S. alone to all renewable sources is likely to exceed \$5T, with worldwide costs of conversion exceeding \$15T in investment. The transition from fossil fuels (particularly coal) will not be linear—and likely come with short term disruptions in total generating capacity and associated blackouts/brown-outs that affect industry output.

Raw material shortages (short- and long-term) will be a second likely fallout:

- Per the Energy Information Administration, over 80% of a barrel of oil is refined to fuel (gasoline, diesel, etc.) The remaining 20% is used in a wide variety of feed-stocks, including petroleum-based additives used in most building materials. Neither economics nor chemistry support shifting a greater percentage of the barrel to secondary petroleum products. Therefore, any move away from fossil fuel-based vehicles will likely carry with it a raw material shortage for construction products until finished goods manufacturers reformulate or find suitable alternatives
- One of the by-products of electricity generation from coal is synthetic gypsum. This material has rapidly gained share in the drywall industry as a lower cost and widely available ingredient. Coal fired electrical generation is the least environmentally friendly alternative available. Therefore, as power generation shifts away from coal, the drywall industry will have to shift to the more expensive natural gypsum (and risk longer term depletion of these natural reserves)
- The 2021 Texas grid failure caused shutdowns in petroleum refining that resulted in disruption in petroleum based raw materials that lasted several months



Labor



The labor market has reached a tipping point in developed countries (and is quickly approaching one globally). Today's labor market is defined by significant demographic, psychographic, and economic shifts that have occurred over several decades. Based on these changes, the construction industry supply chain is not positioned to effectively compete for the young workers.

The Facts

By 2050, the over 65 population in the U.S. will increase from ~16% to over 23% of total population, growing by over 40M (US Census Bureau). Concurrently, according to the Bureau of Labor Statistics, civilian participation in the workforce will decline to 60%, or to all-time lows. The simple fact is that all industries will be competing for a smaller pool of employees at the same time they are losing their most experienced and knowledgeable workers.

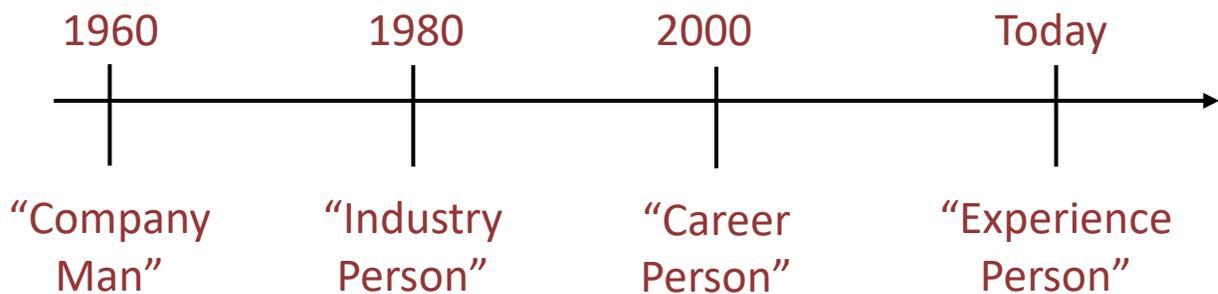
There is already an acute shortage of truck drivers in the U.S. (Industry estimates put this shortage over 100K today and expected to grow to over 160K in the next several years, all as demand increases). No potential pipeline is apparent to close this labor gap.

Manufacturing is not spared. A shortage of skilled factory workers will be exacerbated by a "silver tsunami" of retirements over the next decade. The National Manufacturers Association reports that even conservative estimates predict a shortage of over 2M skilled factory workers in the U.S. by 2030.

Manufacturing, transportation, and construction are often uncompetitive in compensation. According to the Bureau of Labor Statistics' Occupational Employment Statistics, compensation levels in these sectors are as much as 20% below compensation for similar skilled workers / job titles in other industries.



Demographic Shifts



Demographics present a compelling story regarding the changing labor pool. However, equally important is the evolution in employee attitudes and behaviors. Over four generations, there has been a dramatic transition in the way the employee views work and career.

- The 1960's can be considered the era of the “company man”. The workforce was characterized by little movement, as many factory employees stayed with the same company (often the dominant employer in town) for the entirety of his career. The employee's primary objectives were stability and security. This, in turn, assured the employer of a stable workforce
- By 1980, that typical employee had shifted attitudes. The “company man” transformed into an “industry person”. The employee could leverage skills and knowledge across competitors in an industry, and often worked for several competitive or complementary manufacturers over the course of the career. Employees had become more mobile and were willing to trade-off some security for more rapid career advancement. While the employers found greater competition for skilled employees, the “value proposition” offered across all competing employers was often similar
- In 2000, employee mobility reached a new high. The “career person” no longer saw benefit in loyalty to one industry. The emergence of new industries allowed that employee to leverage skills more widely, resulting in greater job movement and more employers over the course of a career. This created a more uncertain environment for the employer as they had much less visibility to what defined a “competitive package” to hire & retain employees
- Today, evolution of employee attitudes/behavior has brought us to an era where experience rules the employee's decision process. A desire for work / life balance is being met with a greater array of employment choices. The new entrant to the workforce today expects to have multiple careers that the 1960's employee would never have envisioned. Employers have had to adjust their thinking to compete across a wider set of variables than just compensation



Labor -- The IMPACTS

The construction industry is not structured to deliver on the “value proposition” that today’s new workforce entrant is looking for. The most likely impact will be a sustained shortage of workers at all levels of the supply chain that will last at least through the next decade.

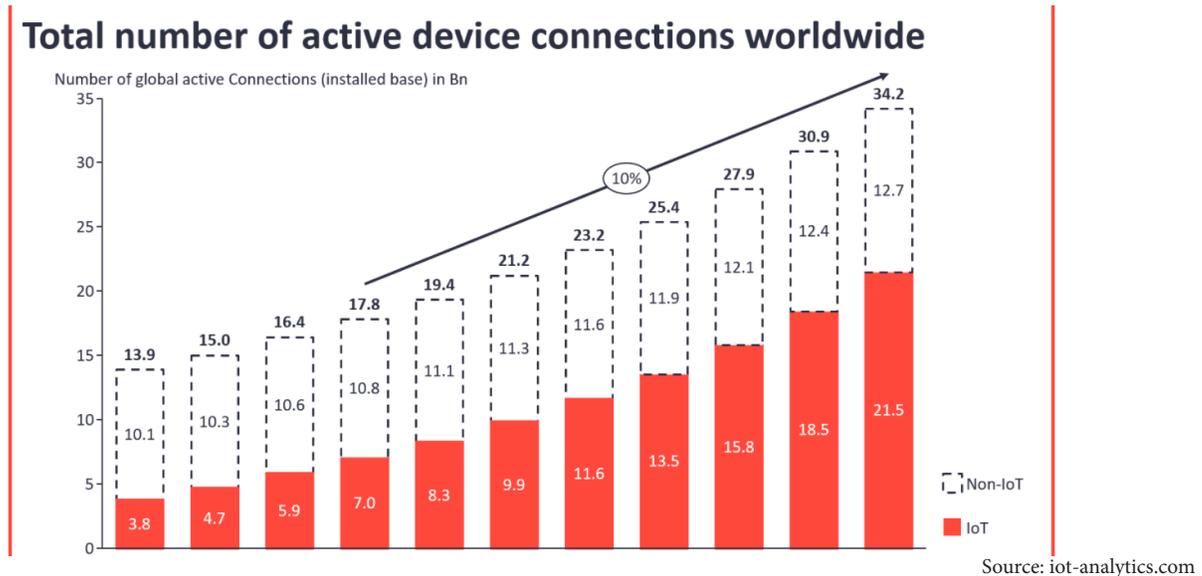
The degree and duration of the shortage will likely be a function of how quickly employers recognize and adjust their value proposition by:

- Providing compensation competitive with other industries
- Providing skills training to offset the lack of trade training available in the U.S. education system
- Providing mobility and career advancement for the experience seeking employee
- Addressing the size and structure of the workforce to allow the desired work/life balance
- Embracing diversity and inclusion to expand the available labor pool
- Modifying the job and work environment to make it less physically demanding for an aging work force



Security and Cybersecurity

In a race to adopt technology to drive efficiency over the last two decades, supply chains are more connected than ever before. And as many participants in the construction supply chain have already learned from experience, security and cyber-security risk is an inevitable consequence of a connected supply chain (and society).



The Facts

The number of connected devices is exploding, forecasted to almost double from 2019 to 2025, per data aggregated by Statista.

Security breaches have increased 11% since 2018 and over 60% since 2014. Concurrently, more dangerous ransomware is increasing as a share of all attacks.

The average ransomware payment is now over \$100K. The U.S. has the highest share of attacks globally (over 18%).

68% of CEOs view their companies as unprepared for cyberattacks, according to the most recent survey on the subject conducted by PWC.

Security experts agree that the growth of IT adoption (and connectivity) is outpacing that of security solutions. And cyberattacks are likely to continue to increase through the middle of this decade. Ransomware attacks are also shifting to infrastructure as it provides the most lucrative target.



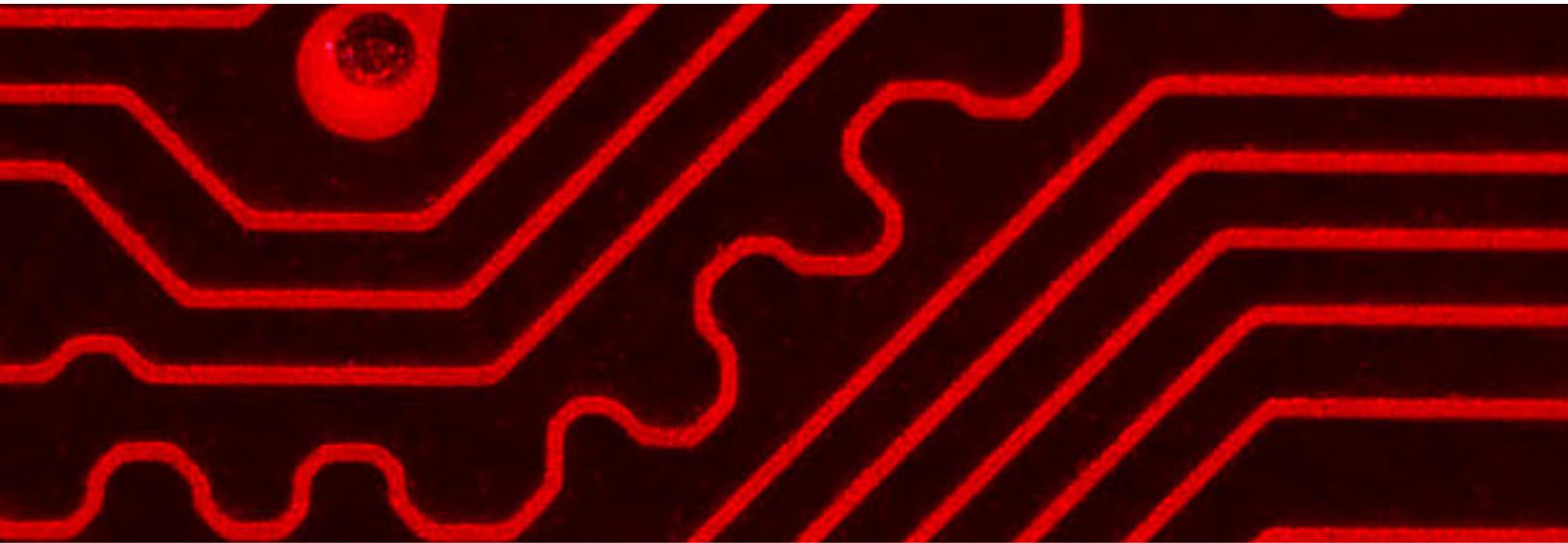
Security and Cybersecurity -- The IMPACTS

“If it is connected, it can be hacked.”

Purchasing managers will be forced to alter strategies, often at the expense of efficiency and cost. Approved materials suppliers may be asked to demonstrate an effective cybersecurity strategy. And an increase on the number of suppliers for each significant raw material may be required to minimize the probability of supply disruptions.

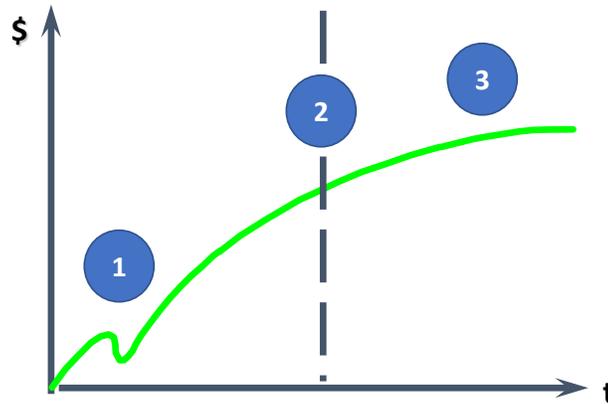
Operations managers will need the ability to “disconnect” critical processes to avoid or reduce impacts of a cyberattack.

These changes in raw material supply and factory operations are likely to result in longer product lead times and higher costs.



Technology and the Market Life Cycle

The rate of technology innovation has been increasing since the 1990's in all business sectors. However, there are still clear “rules of engagement” that drive the rate of adoption of these new technologies. And one of these rules dictates that the process is lengthy and often “messy” with unintended secondary consequences.



The Facts

All new technologies move through a similar adoption path consisting of three stages. The characteristics of each stage and the supply chain issues differ within each.

1. The introductory stage represents the “proof of concept”. Early adopters will employ the technology and go through a period of test and evaluation to validate that the technology delivers the outcomes promised. This validation is based on assessing value across three parameters:

Need—does the new technology fulfill a need not addressed by current (and proven) options?

Economics—Does the new technology provide a tangible economic benefit, expressed as acquisition cost and/or life cycle ownership cost? And at what required investment?

Time—And are there any time constraints (plant or equipment redesign, staffing and recruiting, expiration of existing supply contracts, etc.) that impact the ability of the customer to adopt the new technology?



Technology and Market Life Cycle (cont'd)

2. The growth stage occurs once the market accepts the benefits of the new technology. Growth in the market is characterized by penetration of first-time users. As a result, a premium at this stage is supply chain development—new (or existing) channels of distribution evolve to expand market coverage to the first-time users. And new specialty trade contractor classes may evolve to reflect the sustainable market demand associated with growth. Additionally, many new manufacturers often arise to capture a portion of this growth market
3. Finally, the maturity phase is marked by stability and economics. Most potential users already have experience with the technology and, as such, they transition from first time users to repeat purchasers. With this comes a reduction in perceived risk, which allows the buyer to focus more strongly on the economics around the purchase. As a result, a mature market is often characterized by consolidation in the supply chain—the marginal manufacturers exit the market, and distribution channels consolidate to fewer players who capitalize on scale efficiencies

While the pace of innovation has increased over the last two decades, the timeframe from technology introduction to a “tipping point” in terms of market penetration has not materially changed. There are still ingrained barriers to speeding up the adoption curve. For example, early adopters often require a “use cycle” of several years to prove out new technology efficacy. And the capital costs associated with a new supply chain often can require 10 years or more before full market coverage is achieved. Therefore, for most new technologies, the adoption timeframe is still close to 20 years. As a result, most industry participants routinely overestimate the speed at which technology will be adopted.



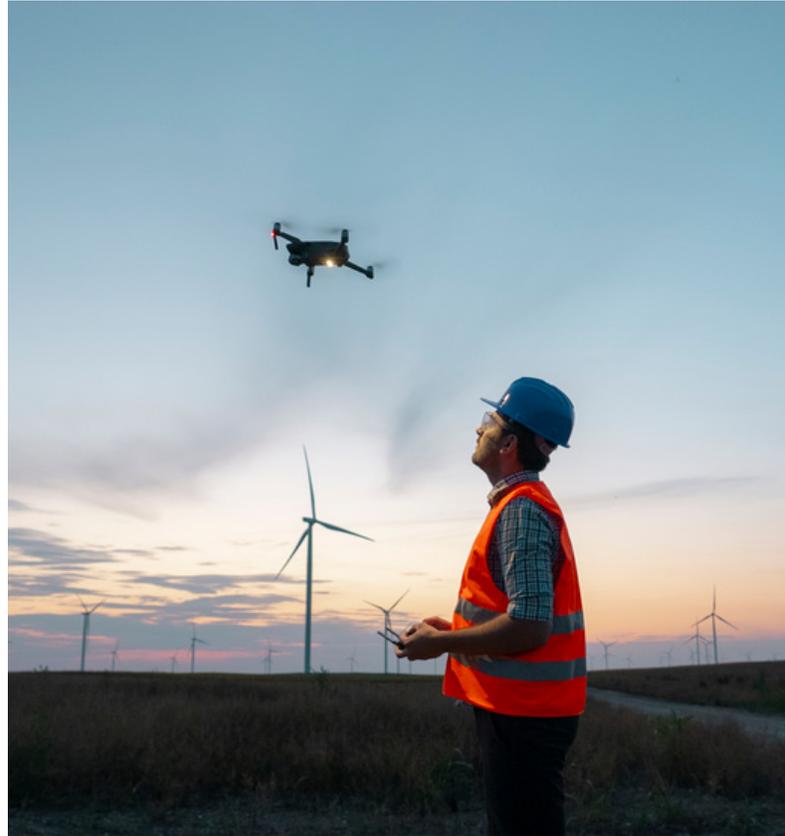
Technology--The IMPACTS

Given the length it takes for new technology adoption, there are often unforeseen secondary consequences. Several secondary consequences of innovation have already been felt by the construction industry. Examples include:

- Online information has resulted in declines in newspaper circulation...which reduced the amount of recycled newsprint, a key raw material in ceilings and drywall manufacture
- Surveys have indicated that the looming threat of self-driving trucks is one of the barriers young workers consider before committing to the transportation industry
- Breakthroughs in battery technology and growth of the electrical charging stations network are expected to dramatically reduce gasoline consumption...reducing refining requirements and putting petroleum based raw materials feedstocks at risk

Over the short- to mid-term (next five to ten years), it is unlikely that new technologies will materially affect most of the supply chain challenges or discrete issues reviewed in this white paper.

In the longer term, technology innovation is likely to be a key determinant of the structure of the supply chain. Through machine learning and robotics, impacts of factory labor shortages will be mitigated. Autonomous vehicles will render a shortage of truck drivers a moot point. Advances in security technologies are likely to lessen the risk and impact of cyberattacks. And innovative new materials, systems, and construction methods will help address both shortages in traditional raw materials and a changing construction job site environment.



Government Regulation and Policy

Winston Churchill wrote a treatise on government—one of his conclusions was that “...the only consistency in government is inconsistency”. If this holds true, government policy promises to be an ongoing “wild card” that is likely to calibrate the rate and severity of impacts on the supply chain over the next decade.

6 Policy Areas

1. Climate
2. Trade
3. Investment
4. Education
5. Workplace Safety
6. Taxes / Economic Incentives

There are six key areas of government policy that are likely to most impact the construction industry—both in terms of what is built, where it is built, when it is built and how it is built, and with the supply chain that supports it.

1. **Climate**—A clear global mandate exists to address climate change. But there are critical unknowns in government response. How quickly will government implement limits on fossil fuels without assurance that enough capacity exists in renewable energy sources? Will countries aggressively implement regulations that could impact the global competitiveness of their industrial base? Will nationalism increase in the face of potential societal “hardships” associated with a transition to clean energy? How will building codes (definitions and enforcement) be changed to help achieve the goal of carbon neutrality?
2. **Trade**—Will tariffs and trade policy limit access to global material sources? In what product/service categories and at what cost? And what domestic incentives and support will be offered to the industries impacted by these trade policies?

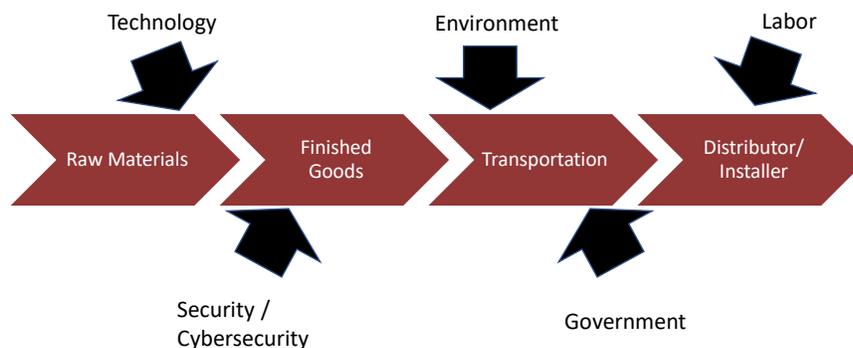
3. **Investment**—What level of sustainable investment (in infrastructure, energy, commerce, etc.) will governments be capable /willing to make? What priorities will emerge for these investments and how do these impact the construction industry?
4. **Education**—Will government policy / investment improve the education system? Will it create a better environment to build the skill-sets of employees who will enter the trades or manufacturing? Will incentives be offered to industry to support employee education?
5. **Workplace safety**—In what form (and over what period) will rules be established for pandemic-related workplace safety (e.g., social distancing)? How will the overall construction processes, timeframes, and costs evolve to meet these new requirements?
6. **Taxes and economic incentives**—How aggressively will governments address taxes and incentives? Will these policies support or present a barrier to economic expansion? How will economic policy influence business reaction to environmental factors? Labor issues? Security and cybersecurity? Technology innovation and adoption?

No consideration of supply chain transition can ignore the impact of government decisions—policy and regulation decisions may serve as one of the greatest catalysts (or hurdles) to change. And what was once a local consideration has gone global. For example, decisions made in Vietnam to improve the competitiveness of their manufacturing will have ripple effects on raw material sourcing and transportation across the globe.



The Impacts and Implications

Each of the five defining themes we have discussed are much broader / deeper than the construction industry and/or supply chains. And it is inevitable that the construction industry will be affected, often in ways that have not even been envisioned yet. But given the scope of the defining themes, in most cases the “how” supply chains are affected will be more important than the “why”.



One example is disruption in supply of major raw materials that shut down manufacturing lines. Another is disruption in supply of minor secondary accessories and additives that are “mission critical” to finished goods manufacture that will slow or stop production. Whether those disruptions are due to a power outage, or a reduction in petroleum refining, the impact on the supply chain is the same.

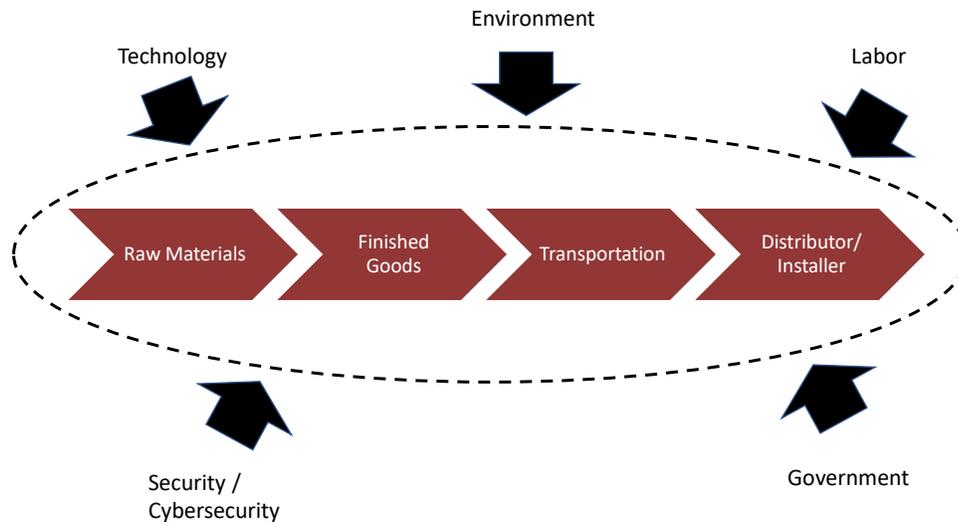
Given the large number of entities that “touch” each other, labor shortages at any stage of the supply chain could create a “domino effect” that dramatically changes the timeframe for the new commercial construction project. Whether the cause was a worker shortage or lack of training... the impact on the supply chain is the same.

No market leader will be naïve enough to believe they can eliminate any potential impact on the supply chain or materially impact the root causes overall. More likely, these market leaders will stay ahead of supply chain disruptions through a series of risk mitigation efforts. These risk mitigation strategies will serve to buffer the leading companies’ supply chains from the disruptive effects of the five root causes.



Market Leaders Will Take a Broad View

The differences between market leaders and their competitors will be visible in many areas.



- 1. Philosophy.** Leaders are likely to take a holistic view of the supply chain. Managers across supply chain functions will be encouraged to become more aware of the upstream or downstream steps in the chain, and the “ripple effects” across the entire supply chain of any decisions they are considering
- 2. Organization.** Leaders will recognize the strategic importance of the defining themes and the supply chain. We are already seeing this reflected in organizational changes—through cross functional supply chain strategy teams and more directly, with new “C” suite representation for functions such as purchasing / procurement, security / cybersecurity, and environment
- 3. Raw Materials.** Leaders will challenge, if not reverse, conventional thinking around efficient sourcing. Rather than consolidating around fewer sources, they may diversify risk by expanding their sourcing partnerships. In new product development, purchasing will become a part of the team, to assure security of supply for all raw materials before new products are scaled up for manufacture
- 4. Finished Goods Manufacture.** Leaders will use multiple tools to minimize disruption in manufacturing. This will likely include automation to boost productivity from a shrinking employee pool. Additionally, more investment in recruiting and training / skill development will allow these companies to hire and retain skilled workers. Leaders may also change the manufacturing footprint, adding or subtracting locations to mitigate risk of disruptions



Market Leaders Will Standout

5. **Transportation.** Leaders will reevaluate the concept of transportation efficiency / effectiveness. This may require a trade-off on economics to assure availability—either through investment in captive fleets or fleet management, agreeing to contract provisions with common carriers to assure priority service, and/or working with distribution partners to assure adequate inventory of product in the last mile
6. **Distribution Strategy.** Leaders will work more closely with distribution partners to modify the value proposition. Finished goods manufacturers will create value-based channel compensation and channel management programs to assure their local distributors are aligned, capable, and motivated to effectively deliver in the “last mile”
7. **Contractor/Installer Relationships.** Leaders will work to assure the availability of qualified installers through contractor selection, management and training. Contractor programs will often include certification and a range of hard / soft benefits to motivate the contractor to engage. These efforts will assure the real estate developer that available, capable, and willing installers will help keep the construction project on time and on budget
8. **Strategic Customer Relationships.** One important change may be in the way that leaders select strategic customers, based on common vision / priorities. And the relationship with these strategic customers will differ—likely creating more and deeper “entanglements” between supplier and customer. For example, regular “state of the supply chain” updates (both within the supply chain and with strategic customers) may become one of the foundational elements of the supplier / strategic customer relationship



Final Thoughts

There is no question that the construction industry supply chains are facing perhaps an unprecedented era of uncertainty. Buffeted by a broad array of economic, political, and societal themes, the industry is learning to work under new rules of engagement—around construction processes and timeframes, materials usage, business models and economics.

To mitigate risk, industry leaders will challenge “conventional wisdom” around all components of their supply chains:

- Securing raw materials supply will yield a new set of decision rules around strategic supplier relationships
- Their manufacturing “footprint” will change to minimize disruptions, while helping their organization meet goals for carbon neutrality
- And stronger partnerships will likely emerge with distributors and installers to assure reliability in the “last mile”

Finally, the new environment should (and will) change the conversation between finished goods suppliers and their strategic customers—likely resulting in new and innovative approaches to building designs, product specifications and vendor choices, as well as construction processes. And ultimately, history may look back and label these new innovative approaches as one of the strategic differences that defined winners and losers in the construction industry through the 2020’s and 2030’s.

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Schedule a quick chat with Carl Cullotta.

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