



**FOLEY**

FOLEY & LARDNER LLP

2020

---

# Accelerating Trends: Assessing the Supply Chain in a Post-Pandemic World

FOLEY.COM

## Accelerating Trends: Assessing the Supply Chain in a Post-Pandemic World

Clients and Friends,

The supply chain is the lifeblood of manufacturing companies. Disruptions to the supply chain caused by COVID-19 have put this into sharp focus.

Even before the coronavirus pandemic, companies were beginning to assess whether their supply chains were meeting the balance between cost-efficiency and resiliency to disruption. The 2020 pandemic provided the ultimate stress test, revealing many supply chain shortcomings that were either previously unseen or not addressed.

As a result, companies are beginning to assess areas of their supply chain that need to be more resilient and to prioritize enterprise investments to achieve additional resilience. These assessments are likely to accelerate certain pre-COVID-19 supply chain improvement trends, including an increased focus on innovation and efficiency and reassessing the geographical locations where manufacturing operations are performed. This report is based on insights from our experience working with middle and upper middle market manufacturing companies, supporting supply chain activities across multiple industries, completing large-scale technology transactions and research on supply chain risk areas and improvement activities among leading organizations. We hope you find these insights valuable to your business and legal considerations.

Best,



**Jay Rothman**  
Chairman & CEO

414.297.5644 | [jrothman@foley.com](mailto:jrothman@foley.com)

## AUTHORS

For more information on any of the topics, please contact our CEO or any of the partners below.



**Ann Marie Uetz**  
313.234.7114  
[auetz@foley.com](mailto:auetz@foley.com)



**Vanessa Miller**  
313.234.7130  
[vmiller@foley.com](mailto:vmiller@foley.com)



**Jim Kalyvas**  
213.972.4542  
[jkalyvas@foley.com](mailto:jkalyvas@foley.com)



**Kate Wegrzyn**  
414.297.5778  
[kwegrzyn@foley.com](mailto:kwegrzyn@foley.com)

We are grateful to the many Foley & Lardner authors who contributed to *Accelerating Trends* and are listed on [page 30](#).



# TABLE OF CONTENTS

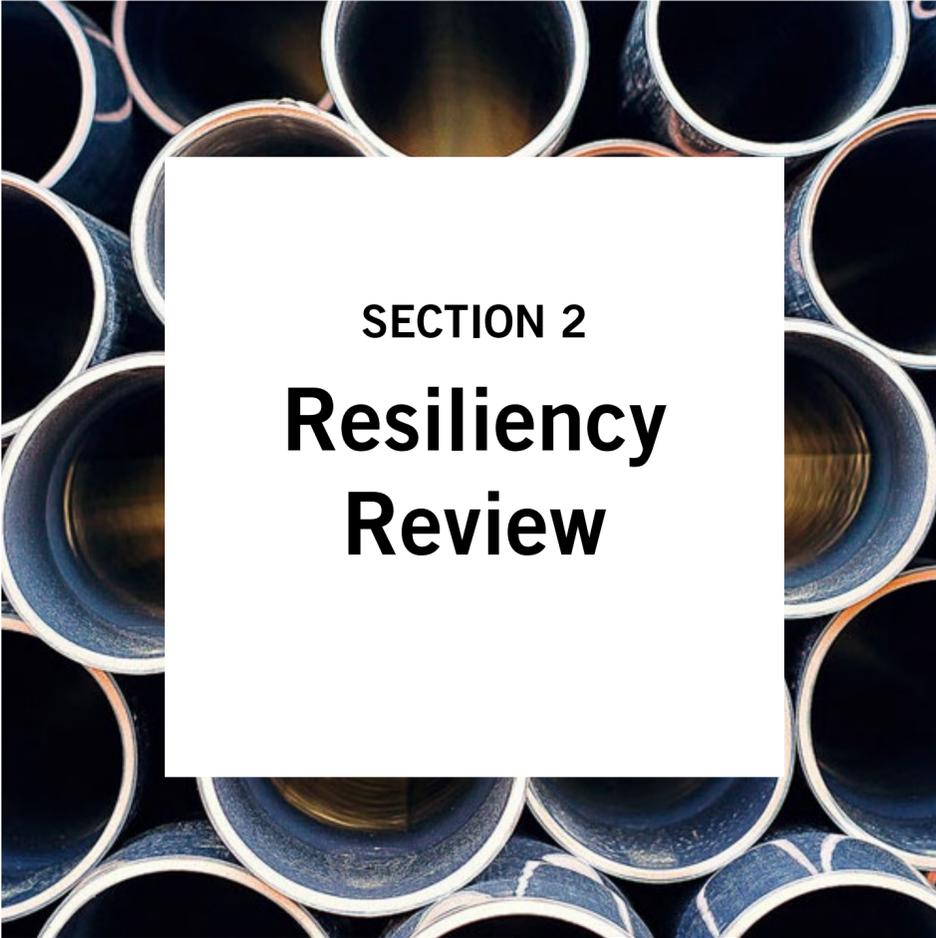
---

This report identifies resiliency and innovation considerations for manufacturers and provides frameworks and tools for you to evaluate how those considerations impact your business.



**SECTION 1**  
**Rethinking  
China**

**GO TO SECTION >**



**SECTION 2**  
**Resiliency  
Review**

**GO TO SECTION >**



**SECTION 3**  
**Innovation  
&  
Efficiency**

**GO TO SECTION >**

An aerial photograph of a modern city at dusk or dawn. The image shows several tall, white, multi-story buildings with balconies, arranged in a grid-like pattern. The buildings are interspersed with green spaces, including trees and small parks. The streets are visible, with some cars and a few people. The overall scene is a mix of urban architecture and nature.

## SECTION 1

---

# Rethinking China

How manufacturers will analyze right-shoring factors to consider the benefits and costs of a shift in supply chains away from China and toward other countries.

# Even before COVID-19, companies were considering whether China continued to make sense for their offshore manufacturing operations.

The U.S.-China trade war caused a sudden and substantial increase in the cost of imported Chinese goods, which catalyzed a shift in U.S. supply chains away from China and toward other countries. In 2019, the total manufactured goods imported to the United States from low-cost countries in Asia (including China), as a percentage of U.S. manufacturing gross output, declined for the first time since 2011.<sup>1</sup> This decline is attributed to reduced imports from China and appears to be correlated with the ongoing U.S.-China trade war.

The global COVID-19 pandemic accelerated and compounded these trends by exposing additional supply chain vulnerabilities. Chief among them was an overreliance on a single, primary source of supply. As some observers correctly note, companies that previously diversified their international supplies in response to the U.S.-China trade war were better positioned to mitigate the effects of the pandemic. **But, when a company decides to reduce its reliance on China, where does it go?**

To determine the right mix of geographic locations for its operations, a company might engage in a “right-shoring” or “best-shoring” analysis, in which a company assesses the most appropriate and effective geographic location or locations for its processes. Right-shoring is a fact-specific analysis driven by commercial, operational, tax, legal, and regulatory conditions in that company’s industry and for that company’s particular product.





A **“right-shoring”** or **“best-shoring”** analysis is a fact-specific assessment conducted by a company to determine the most appropriate geographic location or locations for its processes. The analysis is driven by commercial, operational, tax, legal, and regulatory conditions in that company’s industry and for that company’s particular product.

**Key Factors for Right-Shoring Analysis**

**Outsourcing vs. Offshoring**

**Shoring Buzzwords Defined**

# Where to go from here?

This report provides a high-level overview of manufacturing and sourcing conditions in several of the regions that U.S. companies often consider as alternatives to China. It focuses on reshoring to the United States, nearshoring to Mexico, Brazil, and other Latin American countries, as well as offshoring to India or Southeast Asia. The goal is to provide companies that are considering transitioning away from Chinese suppliers with a framework to understand the costs, benefits, and risks associated with doing business in other locations.

Companies adopting a more diversified approach to their global supply chains may also benefit from retaining certain processes in China while relocating others in a strategic manner that disperses risks of disruption. Partial or piecemeal relocation may also be a useful strategy for mitigating the large capital expenditures that often accompany such undertakings. This is particularly true in cases where significant investments in production, equipment, tooling, and testing are necessary to establish new facilities or qualify new suppliers. In addition, if access to the Chinese market for selling product is an important consideration, that may also weigh in favor of retaining operations in China.

“Companies may benefit from retaining certain processes in China while relocating others in a strategic manner that disperses risks of disruption.”

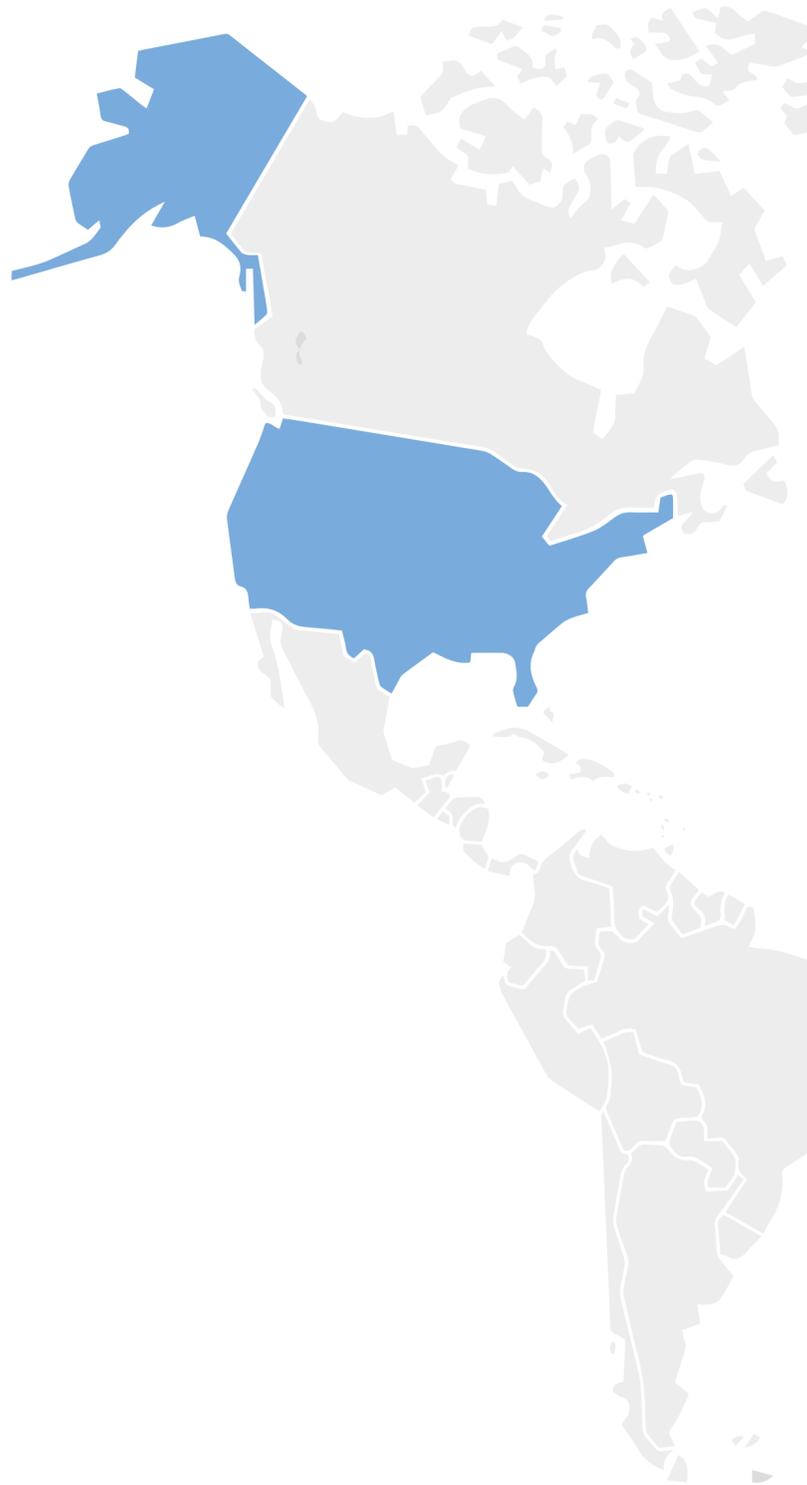
Although this framework compares high-level pros and cons to illustrate key factors, companies undertaking a right-shoring assessment should approach their analysis and decision-making from a holistic, strategic perspective that focuses on their unique business attributes. The right-shoring assessment should include clear distinctions between the core processes that must be directly controlled, critical processes that must be performed or acquired by high-quality or specific vendors, and commodity processes that are easily outsourced.

## WHERE'S EUROPE?

Although Central and Eastern Europe are plausible nearshoring sourcing options for Western European companies, the region is a less popular choice for U.S. companies. Despite a trend of U.S. manufacturers establishing plants in the region in the past decade, it appears that the pendulum may be swinging in the opposite direction, as the recent closing of some U.S. auto plants could signify. Changes in the size of the labor force may be one of the region's downfalls, as the population ages out of the workforce and those of working age may look for opportunities elsewhere. Though Central and Eastern Europe should not be discounted from a global discussion of supply chain shoring activities, the region has been omitted from this report's overview as it is generally not at the forefront of sourcing options for most U.S. companies right now.

# Reshoring USA

Companies may consider reshoring to relocate business processes to the United States. This approach provides for greater coordination and control over products and processes. As U.S. customers increasingly expect instant gratification and enhanced product customization, domestic production may help companies better meet changing levels of demand and consumer preferences and tastes.



UNITED STATES	
PROS	CONS
<p><b>Logistics</b> Inventory is geographically proximate, making lead times shorter and <b>shipping and logistics easier and less costly</b>. This is especially true for larger products, such as appliances, heavy equipment, and machinery, which are more costly to ship on a per-unit basis.</p>	<p><b>Labor Costs</b> Labor costs are high, and shortages of skilled labor are often impediments (though this con continues to be mitigated by increased automation, which generally decreases the amount of labor needed).</p>
<p><b>Control</b> Closer proximity allows for greater oversight of the business processes and quality control, which is ideal for complex designs that require great attention to detail and customization. Risks of certain supply chain disruptions, such as long customs delays, are minimized when processes are handled domestically.</p>	<p><b>Labor Regulations</b> Manufacturing operations in the United States require compliance with a number of employee health and safety regulations, including the Occupational Safety and Health Act, which has thousands of regulations applicable to agriculture, construction, maritime, and all general industries; compliance with these regulations will typically necessitate <b>investments for comprehensive safety and health programs</b>, and, many times, dedicated safety professionals.</p>
<p><b>Trade Issues</b> The use of domestic manufacturing processes <b>eliminates trade and tariff concerns</b> normally associated with these processes when they are offshored.</p>	<p><b>Immigration Restrictions</b> The process for U.S. immigration is complex and time-consuming, making it difficult for diverse talent to move to the United States.</p>
<p><b>IP Protections</b> A company's ability to shut down IP infringement in the United States is extensive via <b>robust IP defense and enforcement options</b>. Accordingly, theft of IP is reduced. China's IP enforcement options, by contrast, are much more limited and usually require the involvement of local governmental actors.</p>	<p><b>Regulatory Structures</b> The extensive regulatory schemes in the United States and the multitude of jurisdictions and agencies that all impact how U.S. laws function have made the United States a less attractive option for manufacturing, particularly on account of associated delays, restrictions, and increased costs.</p>
<p><b>Sustainability</b> Some industries, like the fashion industry, can better focus on sustainable practices when products are manufactured domestically. Companies eliminate or reduce shipping, enhance recycling, and minimize waste when products are made in a localized process.</p>	<p><b>Automation</b> Often, in order to remain cost-efficient, manufacturing in the United States must be <b>extensively robotized</b> with substantial reliance on automation and advanced manufacturing technologies. See Innovation &amp; Efficiency on <a href="#">page 19</a> of this report.</p>
<p><b>Domestic Production Boosting Sales</b> Using domestic materials, parts, and labor in goods may help <b>stimulate sales in the United States</b> due to (a) the regulatory preferences that U.S.-made goods enjoy under government procurement programs, and (b) consumer preference for domestic goods.</p>	<p><b>Property</b> The price of property and facilities costs are higher in the United States than in many other countries.</p>

# Nearshoring Mexico

Companies may move to Mexico for the benefits of nearshoring, in which processes are offshored to a nearby country. This option is growing in popularity, as evidenced by the \$13 billion increase in U.S. manufacturing imports from Mexico from 2018 to 2019.<sup>3</sup>



## MEXICO

PROS	CONS
<p><b>Trade Issues as a Pro</b></p> <p>For Mexico, trade relations with the United States are ordinarily positive. Trade relations between the United States, Mexico and Canada are <b>regulated according to the USMCA</b> (effective on July 1, 2020), the free trade agreement that replaced NAFTA. The USMCA includes favorable considerations regarding trade remedies and temporary relief from certain tariffs.</p>	<p><b>Trade Issues as a Con</b></p> <p>A large number of materials used in manufacturing are not from Mexico, increasing costs associated with the transportation and <b>importation of raw materials</b>.</p>
<p><b>Logistics</b></p> <p>Inventory is geographically proximate, making shipping and logistics easier and less costly. In some instances, depending on the product, the savings on <b>freight and duties can make nearshoring a lower cost option</b> in comparison to China.</p>	<p><b>Security Concerns</b></p> <p>Operations in Mexico can come with increased needs for security for buildings and high-level employees, including hostage insurance, and risks of extortion.</p>
<p><b>Tax Benefits as a Pro</b></p> <p>Mexico has a number of established trade-promotion programs (e.g. IMMEX, VAT Certification), dealing with <b>exemptions on import duties, income, and VAT</b>.</p>	<p><b>Tax Benefits as a Con</b></p> <p>New complex regulations have affected the trade-promotion programs' approval processes, which now stretch beyond the typical 3 weeks to possibly 12 weeks or longer, depending on the Mexican Ministry of Economy workload and criteria.</p>
<p><b>Labor as a Pro</b></p> <p>Labor is inexpensive and, in some cases, less costly than labor in China. The cost of labor in Mexico has recently been reported to be 14% of that of a similarly skilled worker in the United States.<sup>4</sup></p>	<p><b>Labor as a Con</b></p> <p>A recently enacted labor reform decree is projected to <b>increase wages in Mexico</b> in accordance with the USMCA.</p>
<p><b>Geopolitical Stability</b></p> <p>Mexico's government is considered stable, and there is general alignment between the Mexican and U.S. governments' approaches to policy, which may allow for easier partnering for suppliers across borders.</p>	<p><b>Infrastructure</b></p> <p>Additional investments in roads, ports, and infrastructure are likely needed in response to an influx of production in the region.</p>
<p><b>IP Protections</b></p> <p>The <b>USMCA is expected to strengthen IP protection</b> in Mexico. Like the United States, Mexico offers a variety of IP authorities to enforce and defend IP, including the Office of the Attorney General, the National Institute of Copyright, and the Mexican Institute of Industrial Property.</p>	<p><b>Complex Goods</b></p> <p>Mexico has not typically been used by manufacturers—especially those in electronics—for production of complex goods. Instead, production in Mexico is centered on <b>simplified manufacturing</b> and lower technical content.</p>



# Nearshoring

## Other Latin American Countries

Brazil and other Latin American countries also offer the alternative of nearshoring, providing the benefits of working in close proximity while sourcing from a lower-cost location.



### OTHER LATIN AMERICAN COUNTRIES

PROS	CONS
<p><b>Logistics</b></p> <p>Inventory is geographically proximate, making shipping and logistics easier and less costly when compared to China. The need for warehousing and storage facilities may be reduced, as it is easier for companies to utilize just-in-time management of products. Processes are kept within similar time zones, making intracompany communications easier.</p>	<p><b>Security Concerns</b></p> <p>Operations in Latin American countries can come with increased needs for security for buildings and high-level employees, including hostage insurance. Bribery and money laundering are also issues that have previously arisen in some countries in this region.</p>
<p><b>Trade Issues as a Pro</b></p> <p>Ten countries in Latin America have free trade agreements with the United States, including Chile, Colombia, Peru, the Dominican Republic, and most of the countries in Central America. These <b>free trade agreements reduce tariffs and can help streamline cross-border transactions</b>. Brazil and the United States have also announced their intent to further discuss a bilateral trade relationship and potentially a free trade agreement.</p>	<p><b>Trade Issues as a Con</b></p> <p>Delays in customs clearance and a lack of transparency in <b>customs regulations can complicate importing and exporting</b> in certain countries. Countries in the MERCOSUR free trade area (which includes Argentina, Brazil, Paraguay, and Uruguay) also maintain high tariffs on U.S. goods and implement nontariff barriers that can restrain trade.</p>
<p><b>IP Protections</b></p> <p>This region has been progressively increasing the protection and enforcement of its IP laws as a way to attract foreign investors. Various countries (e.g., Chile, Peru, etc.) now partake in the <b>global patent prosecution highway program</b> to enable quicker, easier, and less expensive acquisition of patent rights. Patents, for example, can be secured with little additional expense once a U.S. patent has been granted.</p>	<p><b>Geopolitical Stability</b></p> <p>Countries in these regions experience <b>varying degrees of government stability</b> and must be examined on a country-by-country basis. Some countries have a more pro-business culture than others. For example, the plants of some companies in Venezuela, including General Motors, Kimberly-Clark, and Kellogg's, have been seized by public authorities.</p>
<p><b>Labor</b></p> <p>In general, labor and other operational costs are inexpensive compared to those in the United States, even considering statutory labor rights, such as severance pay.</p>	<p><b>Focus on Commodities</b></p> <p>Latin American countries' manufacturing processes and exports are largely based on a specific range of <b>commodity products</b>, which may indicate that most capabilities tend to be limited to these areas.</p>
<p><b>Local Currency as a Pro</b></p> <p>The costs of manufacturing are low in part due to the devaluation of local currencies.</p>	<p><b>Local Currency as a Con</b></p> <p>Currency fluctuations and potentially unfavorable exchange rates are an impediment to business in the region, since companies assume risks associated with economic uncertainty and instability.</p>
	<p><b>Manufacturing Facilities</b></p> <p>Manufacturing facilities in poorer countries may be less developed than in China from a technical perspective. In some instances, this has resulted in Chinese imports supplanting local Latin American production.</p>

SOUTHEAST ASIA & INDIA

PROS	CONS
<p><b>Labor as a Pro</b>                      Labor costs remain inexpensive compared to the United States and other regions. Cambodia, Laos, and Myanmar are among the countries with the lowest labor costs in the region.</p>	<p><b>Labor as a Con</b>                      Despite generally inexpensive labor, costs are increasing, partly as a means to incentivize skilled workers (although additional factors also contribute). Even though labor costs remain comparatively low, <b>cost increases put economic pressure on suppliers</b>. For example, in Cambodia, labor costs from 1997 to 2019 increased over 450%, possibly contributing to a spike in factory shutdowns in the past year.<sup>5</sup></p>
<p><b>Technological Advancement</b>                      India has experienced a substantial increase in advanced manufacturing investments due to greater availability of skilled labor, quicker product development, and greater government support than in other similar locations. Some countries, like Indonesia and Singapore, have been focusing on <b>growing technology capabilities and digital infrastructure</b>.</p>	<p><b>Logistics</b>                      Products are still 8,000+ miles away, resulting in long lead times and dependency on accurate product forecasting. This can make meeting the two-day shipping expectations of American consumers (part of the so-called “Amazon Effect”) challenging. Stockpiling is often necessary to manage logistics issues with distant manufacturing processes. Stockpiling can restrict cash flow and may <b>impair a company’s ability to adapt to accommodate changing demand</b>.</p>
<p><b>Trade Issues</b>                      Trade and political relations with India and ASEAN countries are generally more favorable than those between the United States and China. Also, the ASEAN Free Trade Area (AFTA) provides for lowered intraregional tariffs among ASEAN members, which increases efficiency and ease of intraregional raw material sourcing for suppliers.</p>	<p><b>IP Protections</b>                      Companies <b>cannot easily protect IP</b> when it remains with a distant supplier, especially in countries with weaker protections. Security measures for IP can also be costly.</p>
<p><b>Financial Incentives</b>                      Countries in this region, including Vietnam and India, offer incentives in the form of <b>preferential tax rates</b> or other similar financial benefits to companies moving from China.</p>	<p><b>Infrastructure</b>                      Infrastructure is generally poor. However, in many countries, significant investment from government (and elsewhere) is driving improvement, and there are pockets of strong infrastructure (e.g., in Thailand, Malaysia, and Singapore). <b>Vietnam’s increasing port congestion</b> is also a discussion topic for businesses.</p>
<p><b>Manufacturing Knowledge Base</b>                      Some countries have institutional knowledge derived from a history of prominent manufacturing industries. For example, Vietnam and Cambodia have a strong base in garment manufacturing practices—an industry that has been in Vietnam for around 30 years.</p>	<p><b>Stability &amp; Security</b>                      Issues like corruption, humanitarian crises, and political instability impact various countries in the region to differing degrees.</p>

# Non-China Offshoring Southeast Asia & India

Over the last decade, a growing number of companies began shifting business processes to India or Southeast Asian countries in response to increased labor costs in China. Members of the Association of Southeast Asian Nations (ASEAN), including Vietnam, Thailand, Singapore, Malaysia, Indonesia, and the Philippines, appear to be the primary beneficiaries.



## SECTION 2

---

# Resiliency Review

How manufacturers will review their processes to ensure a stable and resilient supply chain, focusing on traceability and continuity of supply through diversification or other viable strategies.

# Post-COVID-19, companies are assessing their supply chain processes to determine areas to strengthen and ways to mitigate risk in the future.

The goal is to ensure a stable and resilient supply chain with key focuses on traceability and continuity of supply through diversification or other viable strategies.

To assist companies in identifying significant risks and opportunities which can be addressed through a phased approach and prioritized plan to implement changes, we have developed a customized, on-line assessment tool (link to the right). It describes risks and related considerations each company should review regarding supply chain process changes across five key categories:

- Just in Time (JIT) Production Model
- Single Source Production Scenarios
- Contractual Allocation of Risk/Force Majeure
- Shipping, Warehousing and Inventory Processes
- In-Housing Certain Operations and Services

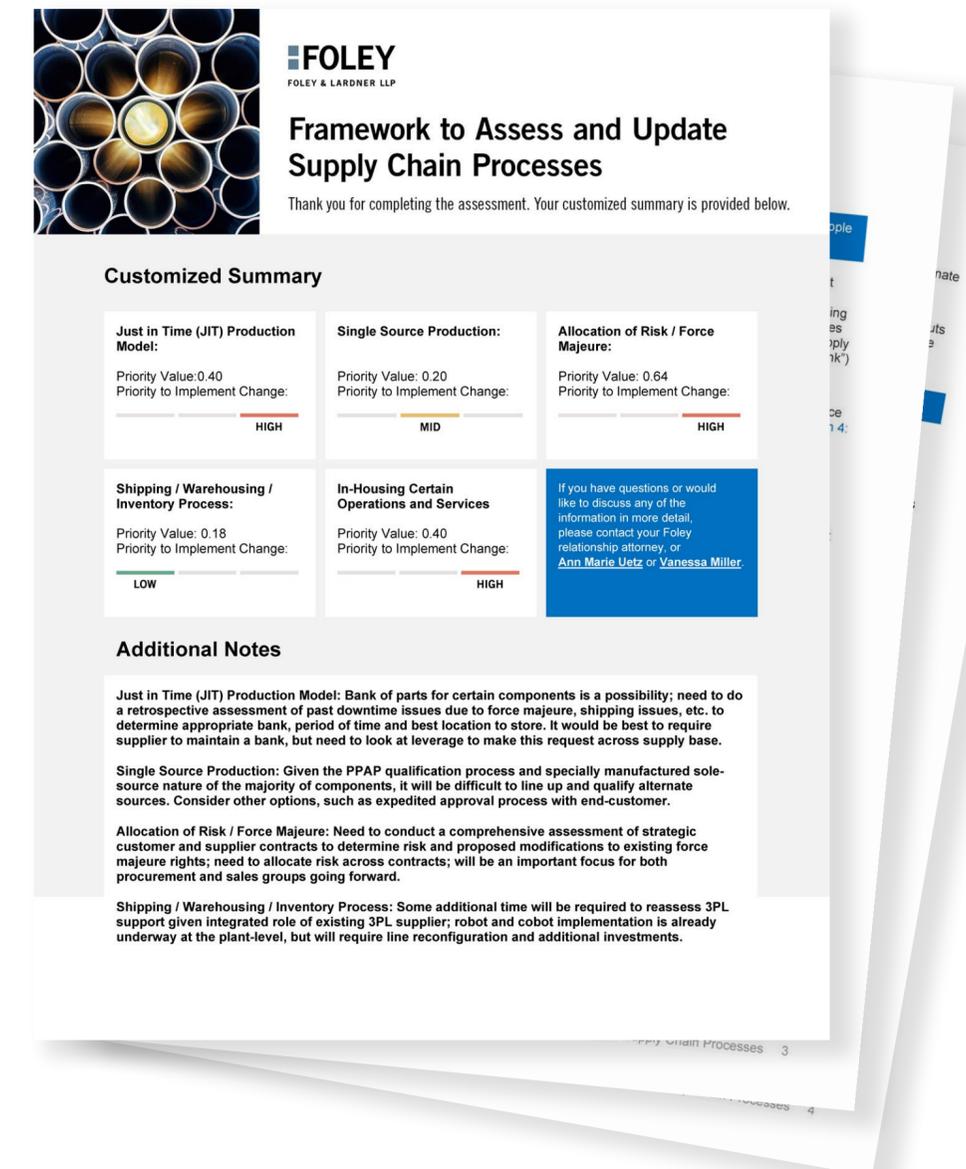
Each category is further described in the pages that follow. Upon accessing the on-line assessment tool, you'll have the opportunity to consider impacts specific to your company, including: Probability of Occurrence (PO) and Probability of Benefit from Change (POBFC), upon which the tool will calculate a Priority Value (PV). You'll receive a priority level indicator of the importance for your company to address potential issues, and implement viable process change. Customized summary results can be e-mailed (and note that no data is stored).

## Framework to Assess and Update Supply Chain Process



CLICK TO ACCESS THE ON-LINE ASSESSMENT TOOL

CLICK THUMBNAIL BELOW TO VIEW A SAMPLE CUSTOMIZED REPORT



# Just in Time (JIT) Production Model

**Just in Time (JIT) Production Model:** Material availability, pricing or demand fluctuations can cause a ripple effect across the supply chain and impact efficiencies associated with JIT inventory models

The COVID-19 pandemic has laid bare the weakness inherent in the JIT production model, which is aimed at reducing times within the production system by aligning orders for materials and component parts with manufacturers' production schedules. While the JIT production model achieves its goal of efficiency by reducing flow times within the manufacturing process, we've now witnessed inefficiencies created by fluctuating volumes and materials shortages. To address this, manufacturers may consider building greater flexibility into their supply base, by requiring an increasing quantity of materials and component parts to be stored (also known as a "bank") for future use.

This will also increase the need to consider additional warehousing to store banks of materials and parts. This approach could provide manufacturers with a greater ability to resource parts from one supplier to another, since the manufacturer would have a bank of parts on standby to use as the new supplier is onboarded. ([See Section 4: Shipping, Warehousing and Inventory Process](#)).

Buyers may shift the burden of building a bank of parts and warehousing costs to their supply base by requiring that suppliers keep a certain amount of inventory on hand. Consideration will need to be given as to how much inventory to bank, whether the goods are perishable, and how frequently the inventory needs to be replenished (e.g., FIFO method: First-In, First-Out assumes that the oldest products in inventory are sold or used first).

Supply chain stress tests – not unlike the financial stress tests which banks have been subject to since the Great Recession – may become commonplace for customers in order to assess the operational and financial health of their supply base. While manufacturers will always focus on reducing costs, they may increasingly rely on other factors, such as the bank build, in order to reduce risk in their supply chain.

## Possible Process Changes

- Customer banks a supply of goods onsite to cover production for a set period of time
- Customer banks a supply of goods for storage offsite to cover production for a set period of time
- Customer shifts the burden to its suppliers by requiring suppliers (and their sub-suppliers) to maintain a bank of goods for a set period of time
- Customer employs FIFO (first in, first out) method to utilize goods on hand
- Customer conducts a retrospective and prospective review to calculate bank quantities

# Single Source Production Scenarios

**Single Source Production:** Expanding options to mitigate the risk in dealing with a sole source supplier

While today's global supply chain is premised on minimizing both lead times and cost, the post-COVID-19 supply chain will optimize stability and resilience by accelerating multilevel sourcing. The supply chain is increasingly viewed as a primary driver of a manufacturer's business, taking center stage since this latest crisis. That means that it must be stable and operate without interruption. As volumes become more variable, being impacted by politics, health crises, and other global effects, supply chains may consider changes to adapt and become more resilient.

Most manufacturers still rely on a single source for the supply of many materials and components. However, stability and continuity of supply may begin to overtake manufacturers' overreliance on piece price as a driver for success. Manufacturers may build supply chain risk into the full piece price, and begin to move away from sourcing decisions based primarily on cost in favor of a more flexible and reliable supply base. Manufacturers may also multisource materials and parts, and work with their customers to develop a preapproved list of alternate suppliers. Digitizing the supply chain will help to expedite the approval process for these alternate suppliers. (See Section 4: Shipping, Warehousing and Inventory Process).

The first step in this process is to map the supply chain, including all suppliers and their sub-suppliers. The inputs need to be traced from raw material to finished goods to understand the flow of the entire supply chain. It will be critical to assess risks based on each input. Risks that need to be considered are shown in the chart to the right.

In addition to triggering events, transportation links between suppliers and their sub-suppliers also need to be considered, such as shipping, air freight, rail transport, etc. Once the highest risk links in the supply chain have been identified, manufacturers should prioritize accordingly to identify and qualify alternate suppliers in different regions that will not be subject to the

Natural Disasters	Plant-Specific Issues	Government-Related	Disease	Other
Acts of God	Plant Fires	Government Action	Quarantines	Riots
Hurricanes	Plant Explosions	Acts of War	Public Health Emergencies	Terrorism
Tornadoes	Floods	Embargoes	COVID-19	Strikes
Earthquakes	Power Outages	Tariffs	Epidemics	Other Labor Issues
Wild Fires	Machinery Issues		Pandemics	
Tsunamis			Other Viruses	
Floods				

same set of risks. Finally, the parties' supply chain contracts may allocate which party will bear the additional costs associated with interruption, switching to an alternate supplier and/or using a different shipping method. (See Section 3: Allocation of Risk/Force Majeure).

### Possible Process Changes

- Mapping process to ascertain suppliers, their site locations, processes and even sub-suppliers
- Dual sources
- Multiple sources
- Work with customer to develop a short list of preapproved alternate sources where limited additional testing is required
- Expedited approval process where customer approval is required to approve alternate source
- Consideration of tariffs and other taxes/costs of production in different or multiple locations

# Contractual Allocation of Risk/Force Majeure

**Allocation of Risk/Force Majeure:** Build in and exercise contractual rights and protections if certain events occur to disrupt the supply chain

The starting point for any analysis of options and rights is the contract. Sometimes the parties will negotiate and jointly execute a long-term supply agreement. However, often in manufacturing, the contractual terms will be comprised of competing form documents—the buyer’s RFP, the seller’s quotation, the buyer’s PO, the seller’s invoice—that incorporate by reference each party’s standard terms and conditions. Prior to COVID-19, many companies’ contracts did not include a force majeure provision. But even for companies that did include a force majeure provision, often it was not a key focus during drafting or negotiations. Instead, it was an afterthought that was copied across long-term agreements and standard terms and conditions, regardless of whether the manufacturer was the buyer or seller and without regard to manufacturing facility locations, geographic risks and weak shipping links. This will change and manufacturers will focus more closely on the contractual force majeure provisions, rights and requirements if either party declares force majeure, and how to allocate other risks associated with business interruption.

Although each supply contract is different, there are some high-level guidelines that manufacturers should consider when tailoring and negotiating force majeure provisions. These considerations will differ depending upon whether the manufacturer is the buyer or seller and the various ways that the supply chain could be disrupted.

## Key Considerations for Buyers

## Key Considerations for Sellers

As with all divergent interests in supply chain contracts, the competing positions of the buyer and seller should be addressed during contract negotiations. For example, if the seller requires a very broad list of circumstances whether foreseeable or unforeseeable that qualify as force majeure events to excuse performance, then the buyer may require that performance resume within a relatively short time frame or the buyer may, at its option, terminate the contract.

In addition to the language of the force majeure provision, there are other contract provisions that manufacturers should strengthen and best practices to implement as a result of lessons learned from COVID-19. When the pandemic began and various executive orders required manufacturers to shutter, there were a flurry of issues that impacted manufacturers. Force majeure notices were sent, but parts already were in transit—who pays for the costs to return those parts when there was no one onsite to receive them? There were situations where a plant in one location had to

be closed, but other manufacturing facilities had capacity—who pays for the costs to tool up and ramp up at an alternate location or for employee overtime? Throughout the pandemic and the reopening phase, there have been additional costs incurred in manufacturing lines, including employee overtime and freight expedites—who pays? These are just some examples of the types of responsibilities and risks that can be allocated in supply contracts going forward.

## Possible Process Changes

- Allocate risk for specific events and circumstances under the terms of the parties' contract; update force majeure and related contractual provisions
- Arbitration to decide who bears the risk on a case-by-case basis, which may include a fee-shifting provision for the prevailing party
- Liquidated damages for force majeure issues: add to piece price/holdback from piece price and hold in escrow pending resolution
- Tracking all costs absorbed as a result of force majeure event to use in future commercial negotiations or discussions regarding cost allocation

# Shipping, Warehousing and Inventory Process

## Shipping/Warehousing/Inventory Process: Improvements to flow and processing of products and materials in the supply chain

As more businesses are implementing AI, big data analytics, and machine learning within their supply chains, there will be an increase in “anticipatory logistics,” where shippers and manufacturers anticipate customer orders before they are actually placed by the customer. According to DHL, anticipatory logistics could enable businesses to analyze customer purchasing patterns in order to preemptively ready themselves for future orders, either by adjusting production ratios to accommodate future orders or by moving existing stock from warehouses to hubs located closer to expected buyers in order to decrease shipping time.

Manufacturers will increasingly move away from paper and digitize their supply chain, which will be critical in order to have real-time visibility into any potential or existing disruptive factors. Digitization will provide manufacturers with diagnostic and predictive insights into their supply base so they can plan for future interruptions and fix problems before they disrupt production. Additional information regarding digitizing the supply chain can be found in this report's [Innovation & Efficiency section](#).

Manufacturers that do not already have freight tracking systems in place should consider digital freight tracking platforms that allow them to track shipments in real time. These platforms track shipments at every stage of transport and provide manufacturers real-time data, in addition to flagging potential issues. These platforms also merge data from various shippers and freight modes to provide a seamless tracking solution. Having this type of visibility allows a manufacturer to react more promptly to any shipping delays or shortfalls. The manufacturer can work to immediately address the issue before continuity of supply is threatened or manufacturing lines are downed.

The pandemic also has provided manufacturers with an opportunity to assess their third-party logistics (3PL) providers' strengths and weaknesses. Since most manufacturers use

3PLs to some extent and some rely heavily on their 3PLs for all aspects of daily operations, the impact of 3PLs on each manufacturer's supply chain will vary. Most manufacturers rely on a single integrated 3PL by region. Just as manufacturers conducted supply chain mapping to identify potential risks and develop contingency plans, so should their 3PL providers. 3PL providers should look at all aspects of the services they provide to the manufacturer and the various regions to determine potential issues and alternate plans with respect to procurement of materials, transportation, tracking shipments, warehousing and inventory management, customs and imports, etc.

### Possible Process Changes

- Implementing technology for end-to-end supply chain connectivity to allow the exchange of information between business partners about sourcing and ordering raw materials
- Implementing technology for end-to-end supply chain connectivity to allow the exchange of information between business partners about tracking transit of components and tracking parts within a warehouse or plant, balancing availability of components with production schedules
- Assessing Third-Party Logistics' (3PL) strengths and weaknesses to prepare contingency plans
- Assessing which tasks can be supplemented by robots, especially for low-value, highly repetitive tasks that are easy to replicate
- Assessing which tasks can be supplemented by cobots (“collaborative robots”) to work alongside humans to improve efficiencies (e.g., handling of materials and objects on assembly lines, including dangerous or toxic materials)

# In-Housing Certain Operations and Services

**In-Housing Certain Operations and Services:** Assess ability to shift certain operations or services away from outside suppliers where there are cost-saving opportunities or continuity of supply issues

In addition to contingency planning by looking at alternative suppliers, many manufacturers are considering whether certain components or processes can be brought in-house. The pandemic provided a natural opportunity for manufacturers to assess whether they have certain in-house capabilities that can be leveraged so that they could avoid disruptions where certain of their suppliers or service providers had shut down. Beyond capabilities, manufacturers will need to determine whether there is a cost-saving opportunity, whether the quality is the same, and whether there are other contractual or logistical issues that need to be addressed if they decide to permanently in-house certain operations.

Looking ahead, manufacturers will want to ensure that they have the contractual right to transfer production or certain operations or services in-house. The manufacturer may want to include a right to in-house if: (a) there is a demonstrated cost-saving opportunity; or (b) the supplier exercises force majeure and is not able to resume performance within a certain amount of time.

The current recession likely provides an opportunity for many suppliers to acquire companies that are financially or operationally distressed, building out a vertical platform for their supply. Although the depth and extent of distress within the manufacturing industry remains unknown, there will most certainly be at least some companies that will not have the capital to continue to operate. Such distressed companies provide acquisition opportunities for others, whether through an out-of-court sale or a bankruptcy sale.

## Possible Process Changes

- Maintain the contractual option to transfer certain operations and services in-house
- Identify what production can be moved in-house, considering pricing issues
- Identify what production can be brought in-house, considering quality issues
- Identify whether there are acquisition opportunities to bring certain production or materials in-house

REMEMBER TO VISIT OUR ON-LINE ASSESSMENT TOOL

[Framework to Assess and Update Supply Chain Process](#)



## SECTION 3

---

# Innovation & Efficiency

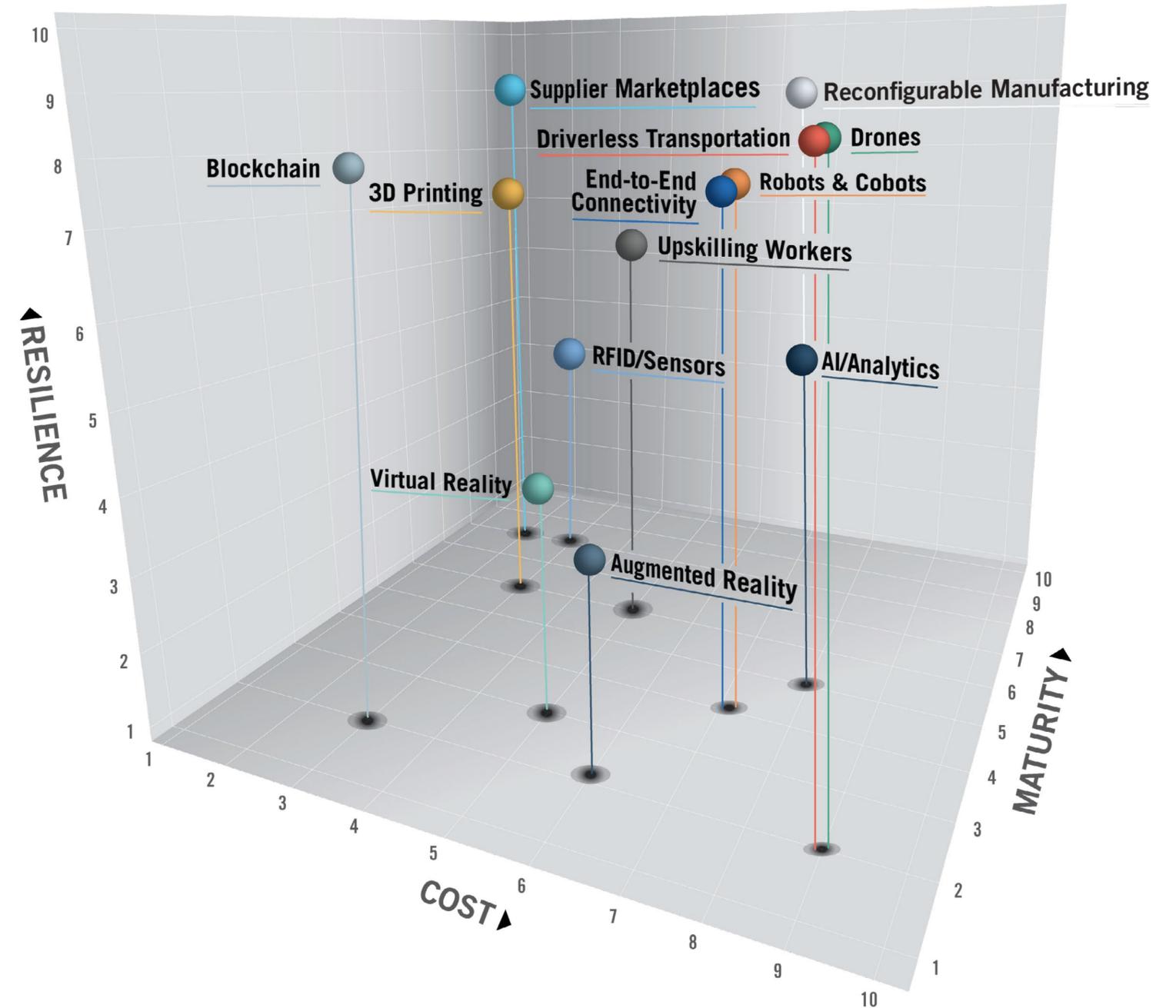
The accelerated use of new technologies and business processes to facilitate innovation and efficiencies.

# The use of new technologies and business processes to facilitate innovation and efficiency in the supply chain has been an evergreen process for decades.

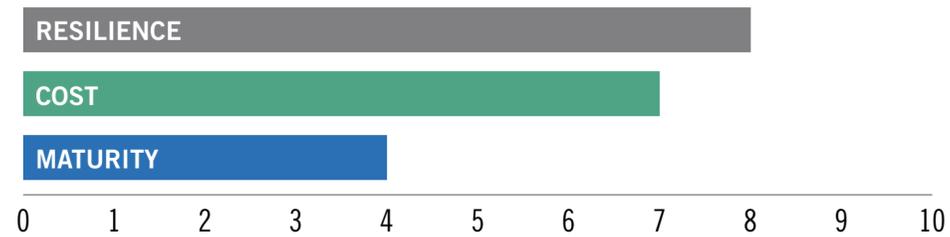
Many exciting new technologies and innovative processes have emerged in the last few years, though widespread adoption in the supply chain has been slow as companies manage competing business imperatives and priorities. The coronavirus and its global impact on supply chain and production issues underscored the importance of supply chain resilience. We expect that the lessons learned from coronavirus impacts will accelerate the adoption of certain technologies below to aid in managing enterprise supply chains and production.

We also project that funding priorities within organizations will be adjusted to elevate investments that respond to supply chain resilience issues. To further assist with that prioritization, we examine several areas of innovation and efficiency in supply chain, and provide our guidance on how the various areas and technologies stack up against each other on the following measures: resilience, cost, and maturity. Our findings are shown in the adjacent graph.

## KEY INNOVATION & EFFICIENCY OPPORTUNITIES



# 1. End-to-End Connectivity / Data Exchange in the Supply Chain

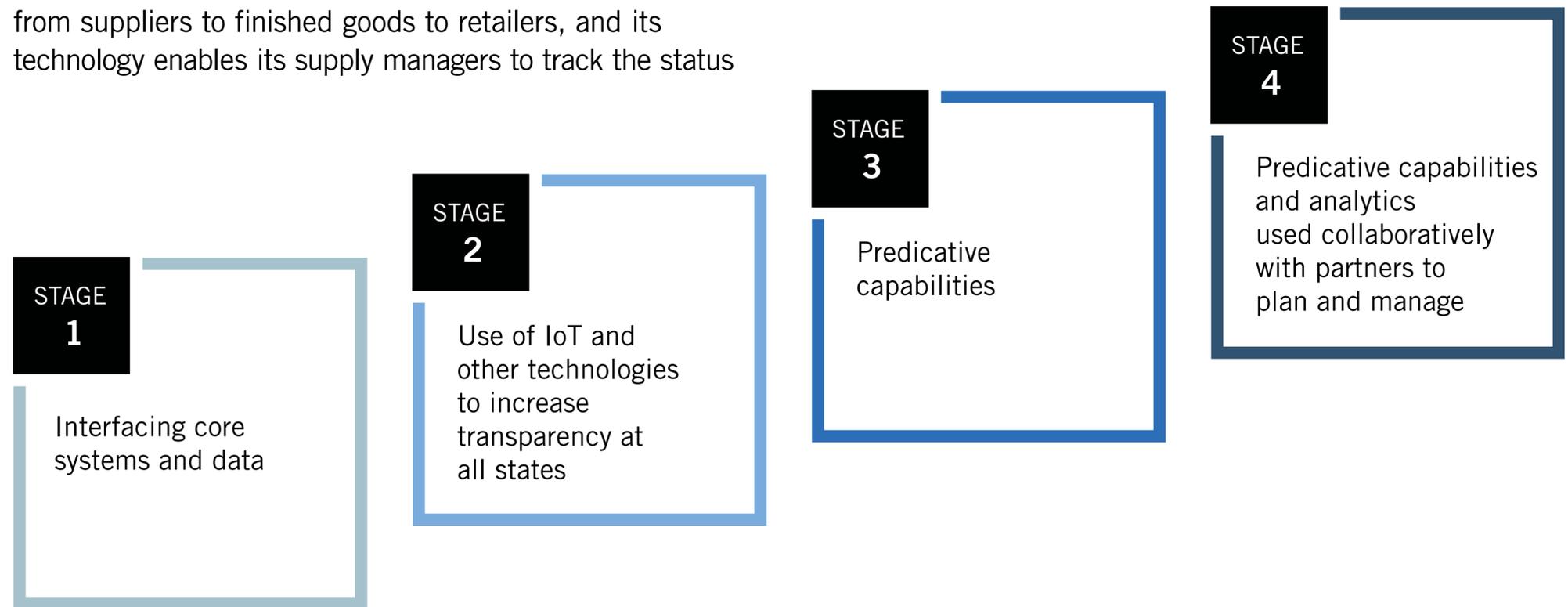


End-to-end supply chain connectivity allows the exchange of information between business partners about all key elements of the supply chain, including sourcing and ordering raw materials, tracking transit of components, tracking parts within a warehouse or plant, balancing availability of components with production schedules, and improving customer delivery.

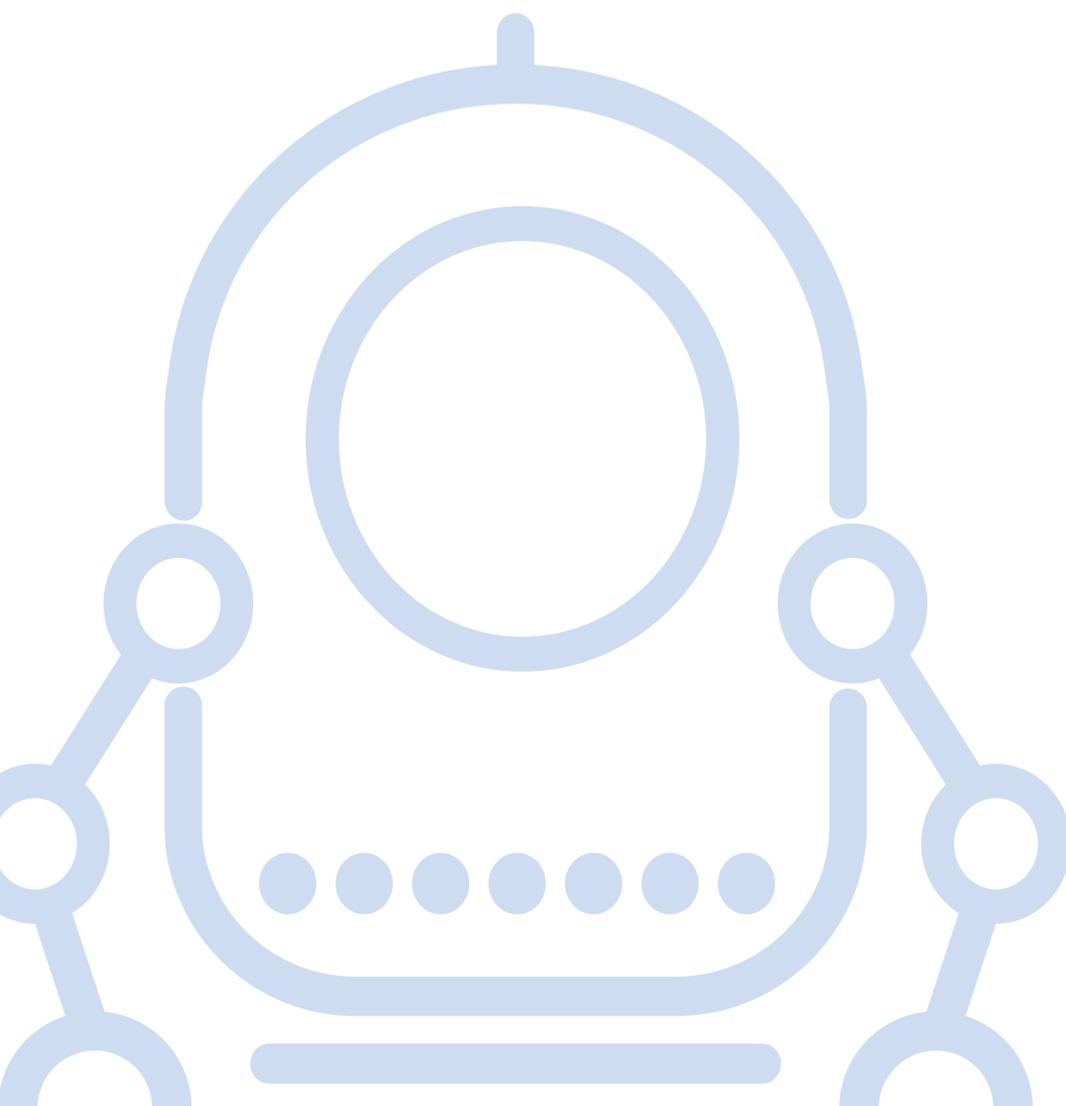
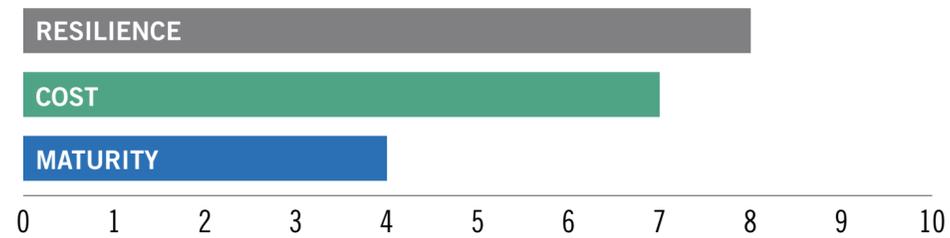
Proctor & Gamble (P&G) has leveraged enterprise applications and advanced analytics to improve its global supply chain, which includes over 130 sites in 180 countries.<sup>1</sup> P&G integrates its supply chain software directly with its suppliers, distributors, and retailers for joint business planning with its supply chain partners.<sup>2</sup> The business planning includes all transportation, from raw materials from suppliers to finished goods to retailers, and its technology enables its supply managers to track the status

of delivery through a single data source.<sup>3</sup> With enhanced real-time visibility of where things move, P&G significantly reduces inventory across the chain and underutilization of its trucks and other equipment.<sup>4</sup>

In addition to Enterprise Resource Planning, Warehouse Management and related software systems, key technologies that manufacturers are using to achieve end-to-end connectivity include Radio Frequency Identification (RFID), a wide variety of sensors and GPS tracking technologies, and some businesses are deploying blockchain as a means of creating a secure and auditable record of all supply chain activities.



## 2. Robots and Cobots



Manufacturing today involves the “melding of the physical and digital worlds.”<sup>5</sup> The implementation of new, advanced technologies, including machines and robots, is rapidly growing. For some tasks, robots have supplemented and, to an extent, replaced human workers on assembly lines. This is especially true for low-value, highly repetitive tasks that are easy to replicate. While the initial implementation of these technologies can be expensive, the automation of repetitive tasks ultimately increases productivity and can lead to cost savings and increased profits. Another benefit that is now sharply in focus is that robots do not get sick.

Cobots, or “collaborative robots,” work alongside humans to significantly improve efficiency in manufacturing and the supply chain. With the use of intelligent cobots, it is estimated that human handling of materials and objects on assembly lines can be reduced by up to 75%, depending on the items being made.<sup>6</sup>

With the inclusion of AI, cobots actually learn from their human counterparts. For example, a robotic arm used to install fragile parts can be outfitted with pressure sensors to teach the arm how much pressure to apply to avoid damaging the part.

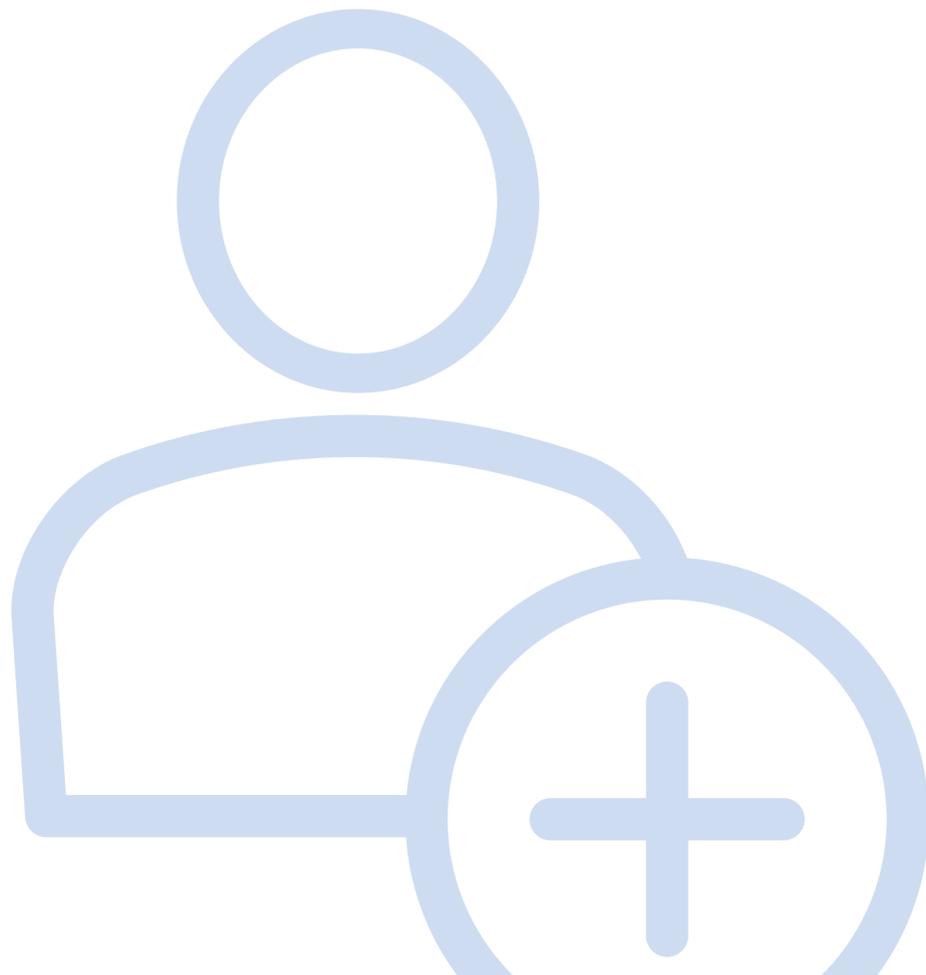
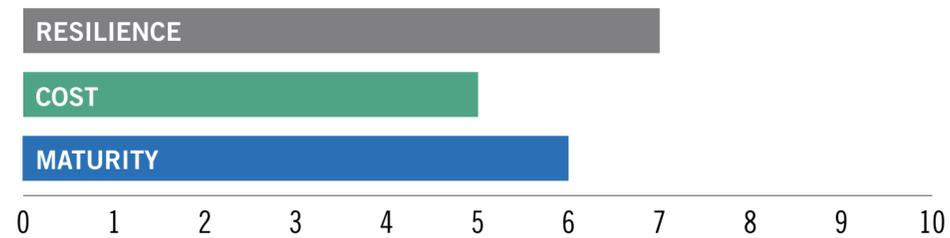
In addition to efficiency and productivity, cobots can contribute to the safety of manufacturing environments. Cobots can perform unsafe or repetitive tasks that, if left to employees, “would carry an increased risk for ergonomic injuries.”<sup>7</sup> Additionally, cobots can learn how to handle dangerous or toxic materials.

With the use of intelligent cobots, it is estimated that human handling of materials and objects on assembly lines can be reduced by up to

**75%**  
▼

Cummins, a global engine, filtration, and power generation product manufacturer and service provider, has doubled its investment in cobots.<sup>8</sup> Cummins reports that “Cobots add significant value” in helping Cummins achieve its goals for improving quality, efficiency, and safety in its manufacturing facilities.<sup>9</sup> Among many others, automotive companies like Fiat, Renault, BMW, and Ford are all using cobots to improve manufacturing quality, production, and/or overall efficiency.<sup>10</sup>

# 3. Upskilling Workers



In line with organizations harnessing innovative supply chain technologies, there is a need to upskill the existing workforce to support the new technologies and work in different ways.

Virtual Reality (VR) and Augmented Reality (AR) are making significant impacts on the ability to train and enhance the speed and efficiency of workers. VR and AR help reduce the need for intensive on-the-job training, and error rates overall. For example, AR can allow instructions and other helpful information to be overlaid on a production line, boosting worker productivity and decreasing the need to be trained intensively on and memorizing such information.

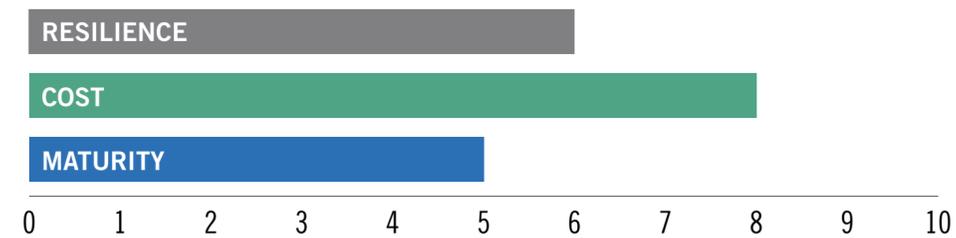
FedEx uses VR in employee training, creating entire warehouses and other environments where trainees can simulate work and demonstrate safety measures with little to no risk.<sup>11</sup> FedEx Ground reports “VR exposes trainees to real work at FedEx . . . and in warehouses . . . , [teaching] them to identify safety risks and solve challenges in a low-risk environment” and with superior results to classroom training.<sup>12</sup>

DHL employees use AR smart glasses, which superimpose pertinent information to direct employees exactly where items should fit on carts while they are picking orders.<sup>13</sup> These smart lenses deliver efficiencies by placing key information, such as picking lists, in constant view of the order picker and directing him or her to the most efficient route through the warehouse, as compared to traditional approaches using paper and hand scanners.<sup>14</sup>

## DEFINITIONS

TERM	DEFINITION
<b>Virtual Reality</b>	A simulated experience that can be similar to or completely different from the real world. Applications of virtual reality can include entertainment and educational purposes. Other, distinct types of VR style technology include augmented reality and mixed reality.
<b>Augmented Reality</b>	An interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory.

# 4. Artificial Intelligence, Big Data, and Advanced Analytics



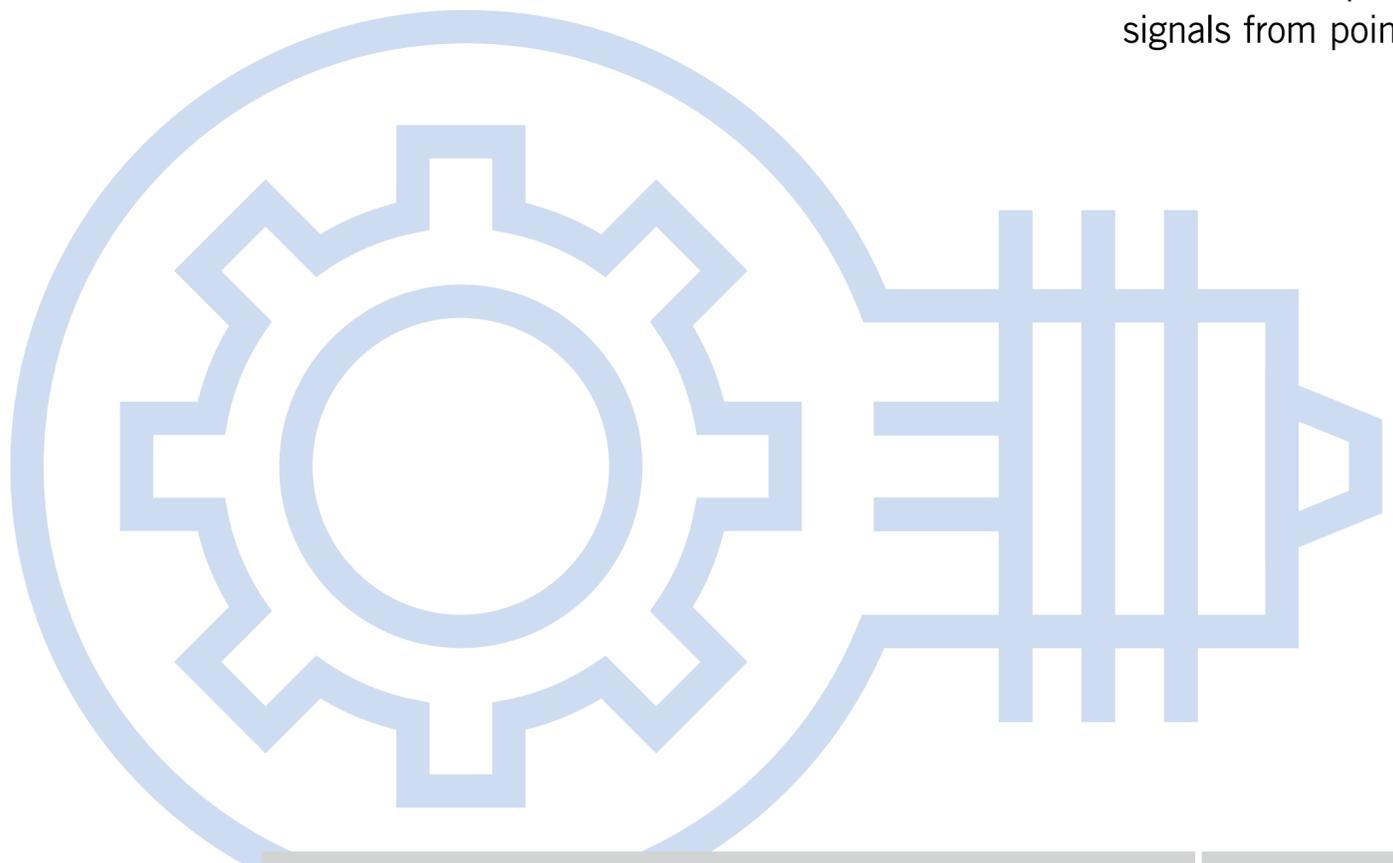
Data has become one of the most valuable currencies in modern business. More and more businesses are going digital, with the result being that a large amount of data is being produced within their supply chains. However, data has limited value without the tools that allow organizations to order, understand, and gain deeper insight from it.

A combination of machine learning and location intelligence helps organizations capture, store, and manage vast amounts of data, run analytics, and then visualize insights in that data.<sup>15</sup> Algorithms can interpret raw images, identify patterns, and make highly accurate product forecasts.<sup>16</sup> Proctor & Gamble (P&G), for example, uses machine learning to forecast demand using historical shipping data.<sup>17</sup> P&G uses “sophisticated modeling to reconcile demand signals from point-of-sale data, retailer warehouse and

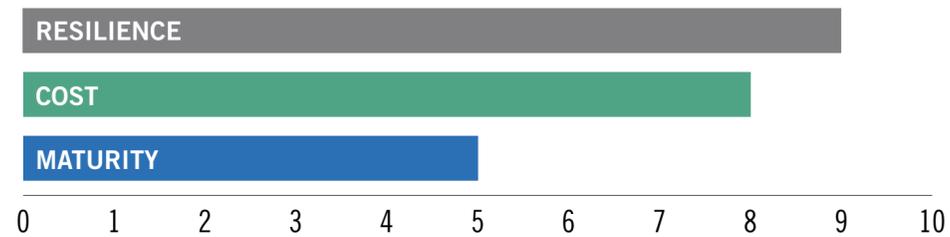
outlet inventory, and retailer forecasts.”<sup>18</sup> P&G, along with Amazon, UPS, Walgreens, and other Fortune 500 companies, is using advanced machine learning algorithms to optimize demand plans for product launches, adjust stocking strategies, and/or find optimal delivery routes.<sup>19</sup>

Algorithms can interpret raw images, identify patterns, and make highly accurate product forecasts.

As more businesses are implementing AI, big data analytics, and machine learning within their supply chains, there will be an increase in “anticipatory logistics,” by which shippers and manufacturers can predict customer orders.<sup>20</sup> According to DHL, anticipatory logistics could enable “businesses to analyze customer purchasing patterns in order to preemptively ready themselves for future orders, either by adjusting production ratios to accommodate future orders or by moving existing stock from warehouses to hubs located closer to expected buyers in order to decrease shipping time.”<sup>21</sup>



# 5. Reconfigurable Manufacturing



In today’s markets, customer demands and needs change quickly. This is where reconfigurable manufacturing comes into play. The versatility and capability to reconfigure a manufacturing line or facility to produce different products provides agility and resilience to adapt to market demands at both a feasible cost and time frame.

Reconfigurable manufacturing systems offer structural adjustments at the control system level, machine level, or both. There are three basic elements that play into designing a reconfigurable manufacturing system:

- (1) the control system, which involves a controller to enable an automated material handling system,
- (2) the material handling system, which involves the selection of material transport equipment that relates to the movement of the parts, and
- (3) the layout design, which involves the physical arrangement of production facilities, such as machines, tools, and plant layout.<sup>22</sup>

A reconfigurable manufacturing system incorporates plug-and-play retrofitting of machines and equipment to change the machine’s properties. Certain machine modules may be predefined in the system architecture to perform certain tasks, while new modules, including add-on software for automatic reconfiguration, may be added as needed. In addition, calibration tools and simulation software is necessary to test and confirm the quick and new changes to the manufacturing system.

Johnson & Johnson’s Vision Care contact lens company has developed an adaptive “modular platform for rapid new product introduction.”<sup>23</sup> Johnson & Johnson has realized a 30% faster time to market on its new Vision Care products as a result.<sup>24</sup> Zymergen, a California bioengineering company, has been investing in creating an automated, high-throughput biomanufacturing system that can be quickly reconfigured.<sup>25</sup> It uses reconfigurable robotics and a large software protocol library from which it can pull, allowing for a more seamless transition from its bio-related R&D to production.<sup>26</sup>



# 6. Driverless Transportation



Companies and logistics providers are constantly looking to shorten delivery times and reduce costs. The focus of pilot programs has been on automated transportation technologies, such as drones, robots, and self-driving vehicles.

## DRONES

Drones have the potential to significantly shorten delivery times, and are generally limited only by their speed, power, and regulation. With last-mile delivery being the most expensive and time-consuming part of the shipping process, drone delivery has the potential to drive big savings and provide a competitive advantage to users of the technology.

Delivery drones in use by Amazon and Google use infrared beacons on the ground to connect with the drones in the air and guide them for delivery.<sup>27</sup> For example, an infrared beacon could be placed in a customer’s backyard or garage for safe delivery, allowing the customer flexibility to determine where safe delivery for the package would take place. This avoids goods being left in an unlocked mailbox or on the front porch of a customer’s house, which are prone to theft, and also avoids delivery to the wrong location.

Amazon plans to develop a drone delivery system to bring packages to customers nearly anywhere within range of certain distribution and drone centers in less than 30 minutes.<sup>28</sup> Google has partnered with FedEx and Walgreens to deliver select packages using drones, such as health and wellness products, including over-the-counter medicines.<sup>29</sup>

## DRIVERLESS TRUCKS

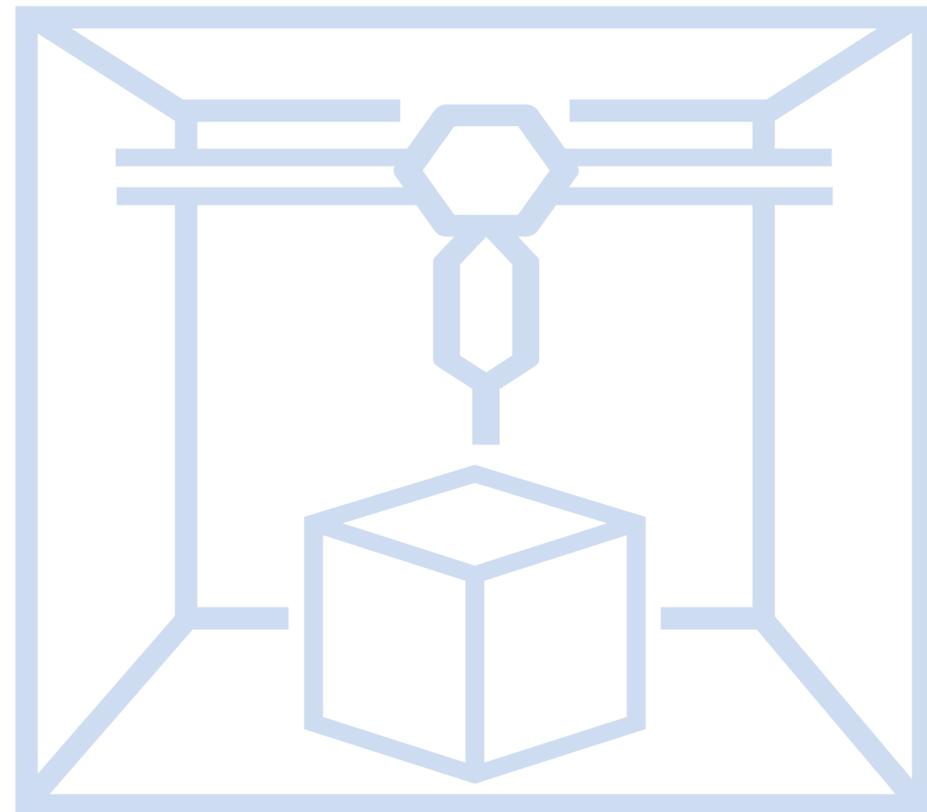
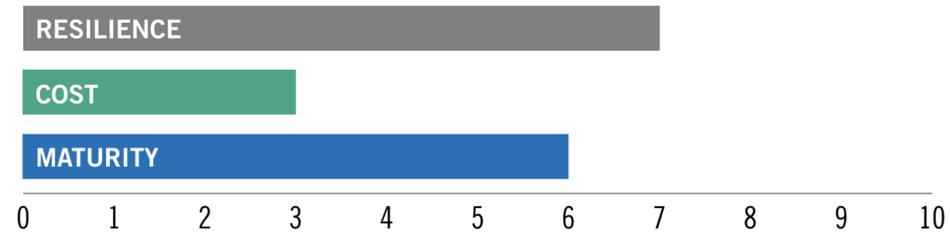
Among other benefits, autonomous trucks and vehicles allow for:

- Savings in labor costs from automating millions of driver positions
- Avoidance of driving-hour restrictions placed on truck drivers
- Increased fuel efficiency with the ability of computer systems to achieve optimal cruising speeds
- Potential reduction in road accidents due to human error<sup>30</sup>

It is most likely that long-distance travel will see this type of technology the soonest, as travel on highways is more predictable than in urban settings, requires less need for human skill to navigate between destinations, and, currently, a large portion of transportation costs arises from the need to employ long-distance truck drivers.<sup>31</sup>

Google patented a smart delivery truck, which has lockers inside the cargo area and customers use a password to access their packages from the locker.<sup>32</sup> Customers receive a message when the vehicle is approaching, and sign upon delivery.<sup>33</sup>

# 7. 3D Printing



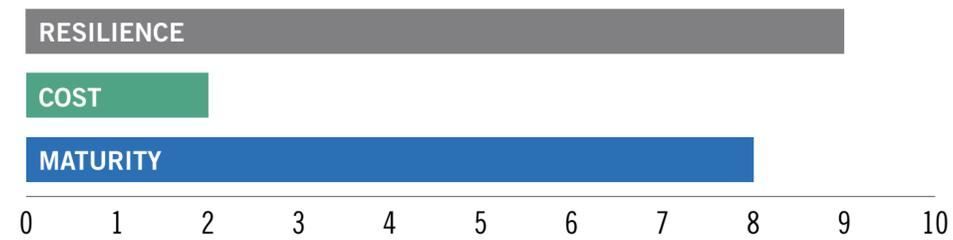
3D printing has the potential to “help companies significantly reduce costs, overcome geopolitical risks [and] tariffs, improve customer service, reduce their carbon footprint, and drive innovation for competitive advantage.”<sup>34</sup> 3D printing, or “additive manufacturing,” “is a process which uses a three-dimensional digital model to create a physical object by adding many thin layers of material in succession.”<sup>35</sup>

3D printers are portable in nature, which enables businesses to take production to local markets or customers faster. As a result, businesses that use 3D printing technology may “shift away from mass production in low-cost countries in favor of more local assembly hubs,” given the ability to produce components closer to home rather than relying on importation.<sup>36</sup> This is a particularly valuable capability in times of global crisis, such as the coronavirus, which makes the importation of certain products significantly more difficult and, in some cases, impossible.

Businesses that use 3D printing technology may shift away from mass production in low-cost countries in favor of more local assembly hubs.

Other innovative traits of 3D printing include its overall resource efficiency in that 3D printing “consolidates the number of components and processes required for manufacturing.”<sup>37</sup> Use of 3D printing can save on production costs and improve product time-to-market.<sup>38</sup> 3D printing overall is greener and more energy- and cost-efficient, creating almost no waste. It is the epitome of just-in-time manufacturing, as products can be “printed” quickly to meet demand.

# 8. Creating Indirect Services Resiliency with Supplier Marketplaces Using Performance-Based Contracts



If, before the current pandemic, your enterprise had three equivalent contracts in place for warehouse and transportation services with pre-qualified suppliers, would your ability to respond have been improved? The model is that by requiring competition between multiple indirect service providers to deliver services in a targeted area (for example, warehouse services), and using a common contract, pricing methodology, and service requirements, you not only establish competitive pricing at the time of contract, but as long as future work is allocated based on

service performance and price, you maintain competition and the “win-your-business” supplier attitude that otherwise dissipates quickly after contracting is complete. In addition to the service quality and pricing benefits, you are creating a bench of capability in the service area, such that if there is an issue with one supplier, another is ready to quickly absorb the load.

Other value from creating a supplier marketplace for certain indirect service lines comes from the following:

- Create and maintain a smaller, but more expert, internal supplier management capability
- Drive the suppliers toward continuous performance improvement and savings
- Achieve uniform service delivery commitments
- Use common agreements that can be uniformly managed and administered
- Create common performance measures/service levels
- Enable comparison of vendor performance to maintain supplier competition
- Create a pricing model aligned with your consumption and business objectives

# APPENDIX

---

ATTORNEY ADVERTISEMENT. The contents of this document, current at the date of publication, are for reference purposes only and do not constitute legal advice. Where previous cases are included, prior results do not guarantee a similar outcome. © 2020 Foley & Lardner LLP

We are grateful to the many Foley & Lardner authors who contributed to *Accelerating Trends*, including:

## AUTHORS

---

### Rethinking China

**Authors:** Kathleen E. Wegrzyn and Stephanie M. Cash

### Resiliency Review

**Authors:** Ann Marie Uetz and Vanessa Miller

### Innovation & Efficiency

**Authors:** Jim Kalyvas

## CONTRIBUTORS

---

Richard H. Casper, Elliott Gurnick, Steven H. Hilfinger, Daniel A. Kaplan, Marcos Carrasco-Menchaca, Alexander J. Neuworth, Erika Padilla, Pedro Romano Fragoso Pires, Alejandro Gómez-Strozzi, Christopher Swift, Nicholas J. Zepnick

## RETHINKING CHINA: FOOTNOTES

- 1 See Patrick Van den Bossche et al., Trade War Spurs Sharp Reversal in 2019 Reshoring Index, Foreshadowing COVID-19 Test of Supply Chain Resilience, KEARNEY, [https://www.kenarney.com/documents/20152/5708085/2020%20Reshoring%20Index.pdf/ba38cd1e-c2a8-08ed-5095-2e3e8c93e142?t=1586268199800&utm\\_medium=pr&utm\\_source=prnewswire&utm\\_campaign=2020ReshoringIndex](https://www.kenarney.com/documents/20152/5708085/2020%20Reshoring%20Index.pdf/ba38cd1e-c2a8-08ed-5095-2e3e8c93e142?t=1586268199800&utm_medium=pr&utm_source=prnewswire&utm_campaign=2020ReshoringIndex) (last visited June 12, 2020).
- 2 Supply Chain Strategies Under the Impact of COVID-19 of Large American Companies Operating in China, PRICEWATERHOUSECOOPERS CONSULTING LIMITED, ET AL. (April 2020), <https://www.amchamchina.org/uploads/media/default/0001/12/6c49fa07fc17aad5eae5d40b592b0fbb185ea1f.pdf>.; Morgan Forde, ISM: Lead Times Are Up 200% or More Across the World, SUPPLY CHAIN DIVE (Apr. 15, 2020), <https://www.supplychaindive.com/news/coronavirus-ism-lead-times-supply-chains/576070/>.
- 3 Van den Bossche et al., supra note 1.
- 4 Van den Bossche et al., supra note 1.
- 5 Chen Gong & Yu Zhongxin, Cambodia and Vietnam in the US-China Trade War: Not All Good News, DIPLOMAT (July 2, 2019), <https://thediplomat.com/2019/07/cambodia-and-vietnam-in-the-us-china-trade-war-not-all-good-news/>; Michelle Jamrisko & Xuan Quynh Nguyen, Vietnam Becomes a Victim of Its Own Success in Trade War, BLOOMBERG (Sept. 17, 2019), <https://www.bloomberg.com/news/articles/2019-09-17/vietnam-becomes-a-victim-of-its-own-success-in-trade-war>.
- 6 Van den Bossche et al., supra note 1.

## INNOVATION & EFFICIENCY: FOOTNOTES

- 1, 2, 3, 4 *End-to-end Supply Chain Model*, Technology and Operations Management, Harvard Business School Digital Initiative, <https://digital.hbs.edu/platform-rctom/submission/pg-end-to-end-supply-chain-model/>.
- 5 Karen Sammon, *Fourth Industrial Revolution Demands “New Forms of Multi-Stakeholder Collaboration*, Conscious Capitalism, <https://www.consciouscapitalism.org/blog/fourth-industrial-revolution-demands-new-forms-of-multi-stakeholder-collaboration>.
- 6 Peggy Hollinger, *Meet the cobots: humans and robots together on the factory floor*, Financial Times, <https://www.ft.com/content/6d5d609e-02e2-11e6-af1d-c47326021344>.
- 7 Collaborative robotics: Leading the way in Industry 4.0, Cummins Newsroom, <https://www.cummins.com/news/2019/11/13/collaborative-robotics-leading-way-industry-40>.
- 8, 9 Steve Crowe, *Cummins more than doubling cobots working at manufacturing plants*, Collaborative Robotics Trends, <https://www.cobottrends.com/cummins-more-than-doubling-cobots-at-manufacturing-plants/>.
- 10 Magneti Marelli Slovakia, *UR Cobots Reduce Error-Rate and Increase Assembly Line Speed by 25% at Magneti Marelli*, Universal Robots, <https://www.universal-robots.com/case-stories/magneti-marelli/>; *Which Companies are Using Collaborative Robots to Improve Production Cycles*, Cobot Intel, <https://cobotintel.com/techman-ca/companies-using-collaborative-robots-to-improve-production-cycles/>.
- 11, 12 Morgan Forde, *FedEx Ground using virtual reality to train, retain workers*, Supply Chain Dive, <https://www.supplychaindive.com/news/fedex-ground-using-virtual-reality-train-retain-workers/567235/>.
- 13, 14 Andrew Arnold, *How AR and VR Are Revolutionizing the Supply Chain*, Forbes, <https://www.forbes.com/sites/andrewarnold/2018/01/29/how-ar-and-vr-are-revolutionizing-the-supply-chain/#306e39e4cbf1>.
- 15, 16 Yasman Kazemi, *AI, Big Data & Advanced Analytics in the Supply Chain*, Forbes <https://www.forbes.com/sites/yasamankazemi/2019/01/29/ai-big-data-advanced-analytics-in-the-supply-chain/#613c048d244f>.

## INNOVATION & EFFICIENCY: FOOTNOTES, CONTINUED

---

- 17, 18, 19** Karen Kim, *Artificial Intelligence in Supply Chain Management*, Disruptive Competition Project, <http://www.project-disco.org/innovation/071919-artificial-intelligence-in-supply-chain-management/>.
- 20, 21** Brian Hoey, *How Artificial Intelligence Will Impact the Global Supply Chain*, Flexis, <https://blog.flexis.com/how-artificial-intelligence-will-impact-the-global-supply-chain>.
- 22** Azrul Azwan Abdul Rahman, *Revolution of Production System for the Industry 4.0*, IntechOpen, <https://www.intechopen.com/books/mass-production-processes/revolution-of-production-system-for-the-industry-4-0>.
- 23, 24, 25** Global Lighthouse Network: Insights from the Forefront of the Fourth Industrial Revolution, World Economic Forum, [http://www3.weforum.org/docs/WEF\\_Global\\_Lighthouse\\_Network.pdf](http://www3.weforum.org/docs/WEF_Global_Lighthouse_Network.pdf).
- 26** *How We Do It*, Zymergen, <https://www.zymergen.com/how-we-do-it/>.
- 27** Stacy Liberatore, *Google patents self-driving Trucks*, Daily Mail, <https://www.dailymail.co.uk/sciencetech/article-3439733/Google-patents-self-driving-TRUCKS-Delivery-vehicles-use-smart-lockers-allow-customers-pick-goods-kerbside.html>.
- 28** RMIT University, *Drones and driverless trucks*, Future Learn, <https://www.futurelearn.com/courses/omni-channel-retailing/1/steps/158063>.
- 29** *Why Amazon, UPS and even Domino's is investing in drone delivery services*, Business Insider, <https://www.businessinsider.com/drone-delivery-services>.
- 30** RMIT University, *Drones and driverless trucks*, Future Learn, <https://www.futurelearn.com/courses/omni-channel-retailing/1/steps/158063>.
- 31** Karter Smith, *Impact of Autonomous Vehicles in Your Supply Chain*, Baton Global, <https://www.batonglobal.com/post/impact-of-autonomous-vehicles-in-your-supply-chain>.
- 32, 33** Stacy Liberatore, *Google patents self-driving Trucks*, Daily Mail, <https://www.dailymail.co.uk/sciencetech/article-3439733/Google-patents-self-driving-TRUCKS-Delivery-vehicles-use-smart-lockers-allow-customers-pick-goods-kerbside.html>.
- 34, 35, 36, 37, 38** Simon Knowles, *Five Ways 3D Printing Will Impact The Global Supply Chain*, Maine Pointe, <https://www.mainepointe.com/practical-insights/five-ways-3d-printing-will-impact-the-global-supply-chain>