



# Supply Chains Post COVID-19

**Harvard College Consulting Group**

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## 2. Executive Summary

The COVID-19 pandemic plunged the global economy into the deepest recession since the end of World War II: In 2020, the economy **contracted by 3.5%, a 7% loss compared to the projected growth** for that year. The HCCG team conducted a combination of expert interviews and secondary market research to examine the current and future effects of this pandemic on global supply chains.



To break down the effects of COVID-19 on supply chains, HCCG examined 4 key industries:



Healthcare



Consumer Retail



Technology



Aviation + Defense



### PRE-COVID LACK OF FLEXIBILITY & CLARITY

In the pre-pandemic era, there was a **strong commitment to fixed, singular suppliers in specific geographic regions**, like China, that were particularly hard hit by COVID-19. A lack of data-based optimization throughout complex supply chains, especially in the retail and technology industries, introduced **significant inefficiencies and mismatches between supply and demand**.

### DECREASED MANUFACTURING CAPACITY & SPEED



As a result, COVID-19 caused **severe supply chain disruptions as manufacturing plants shut down or reduced production** to comply with public health regulations and faced upstream shortages regardless of whether demand for products had increased (such as in healthcare industry and technology) or decreased (such as in aviation and consumer retail).



### FUTURE DIVERSIFICATION & DIGITIZATION

In response to the weaknesses illustrated by COVID-19, many industries are looking **to increase the diversification and digitization** of their supply chains to improve their resilience and efficiency. Industries are also restructuring their supply chains in a variety of ways, **reallocating resources, and changing internal processes** to better address these shortcomings.

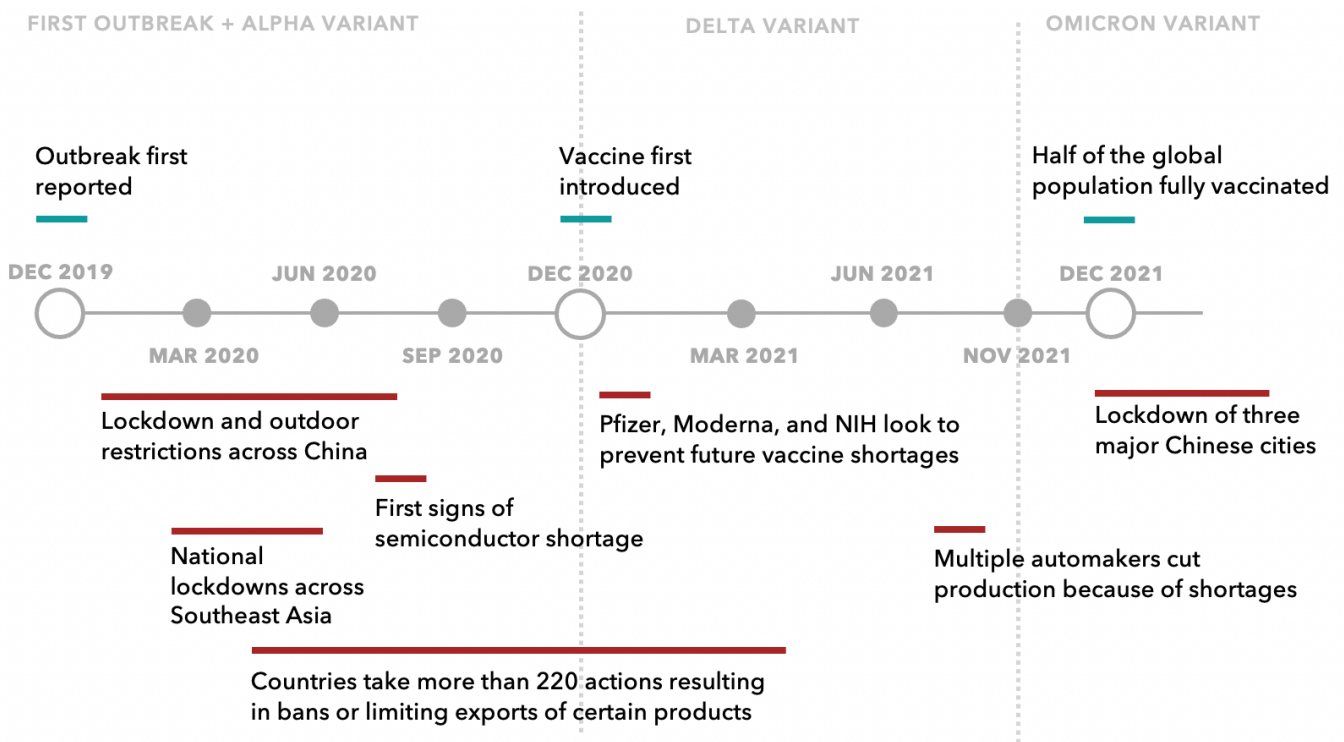
### 3. Introduction

The emergence of the COVID-19 pandemic has caused devastating disruptions in all aspects of life. For businesses, the virus resulted in massive disruptions in global supply chains, leading to **economic losses and changes in the way firms operate and create goods**. Throughout this paper, we discuss four major industries affected by the pandemic – **healthcare, consumer retail, aerospace/defense, and technology** – and examine how each industry’s supply chain has been altered.

These four industries were selected as ones that each had unique, significant responses to COVID-19: the healthcare industry was immediately impacted by this global pandemic, providing personnel, drug discovery, and medical care; the consumer retail and aerospace/defense industries were hard hit by government quarantine and lockdown restrictions with their normal customer bases rapidly dwindling in size; the technology market faced a sharp increase in demand as school and work transitioned to virtual formats.

The disruptions caused by COVID-19 exacerbated problems each industry was already experiencing relating to their supply chains. These complications led to numerous shortages experienced all around the world.

**Exhibit 1. A general timeline of the COVID-19 pandemic and its effects on the major industries discussed in this paper.**



## 4. Pre-COVID Industry Trends



To complete a holistic comparison of supply chains pre-pandemic to post-pandemic, HCCG examined how the consumer retail, high tech, healthcare, and aerospace/defense industries were affected by COVID-19. Using both primary and secondary research, HCCG first assessed the world of each sector before the onset of the pandemic in early 2020. Most notably, companies in these four sectors had **supply chains that were heavily dependent on a single supplier or a single geographic area**. Additionally, **a lack of optimization and data usage created inefficiencies** in the services provided. These factors created significant weaknesses that were aggravated by COVID-19.

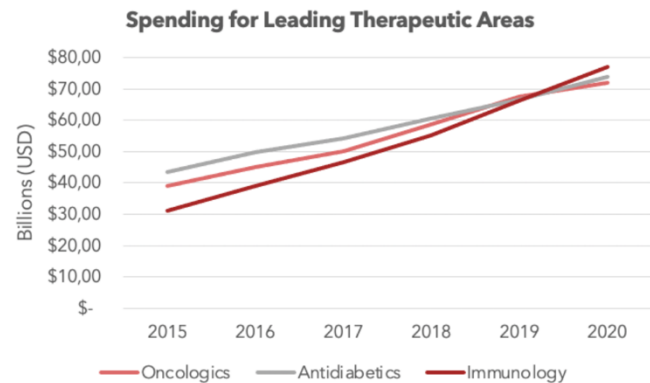
### 4.1 Healthcare

Before the COVID-19 outbreak, the global pharmaceutical industry's revenues grew to reach **\$1.2 trillion in 2019**.<sup>1</sup> Traditionally, the pharmaceutical supply chain would follow 4 key steps: first, active pharmaceutical ingredients (APIs) are produced in manufacturing hubs. Then, they are processed into finished goods (either in the same facility or a different one) and go through the delivery process, ultimately reaching the warehouse at the destination country. From here, they are delivered to their final point of dispensing (for example hospitals, pharmacies, or directly to health care providers). The three leading therapeutic areas based on spending before the pandemic were immunology, oncology, and antidiabetics, with spending varying between \$66 and \$67 billion for all three areas.<sup>2</sup>

Exhibit 2: The pharmaceutical industry had been experiencing steady growth pre-pandemic.



Exhibit 3: Spending for leading therapeutic areas is trending up, with immunology growing especially quickly.



The three main trends that shook the pharmaceutical industry before the beginning of the pandemic were **increased transparency, increased expenditure and outsourcing of R&D operations, and growing adoption of digitization and big data**.

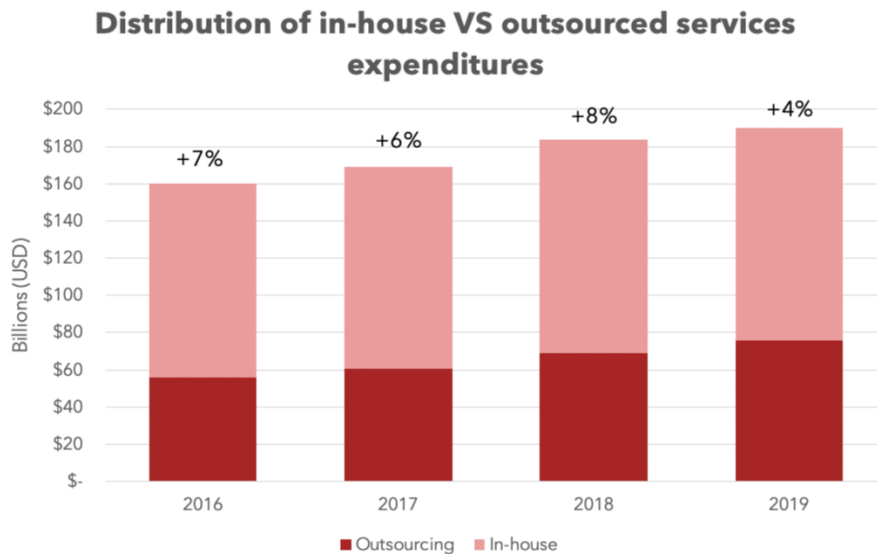
<sup>1</sup> IQVIA, [Global Medicine Spending and Usage Trends - Outlook to 2025](#)

<sup>2</sup> IQVIA, [Medicine Spending and Affordability in the United States \(2020\)](#)

According to the 2018 Edelman Trust Barometer, there is general public distrust of the pharmaceutical industry, with US **consumer trust at only 38% of the population.**<sup>3</sup> The pharmaceutical industry is gradually becoming more aware of this need for increased transparency, with the FDA’s 2013 Drug Supply Chain Security Act (DSCSA) requiring all stakeholders in the pharmaceutical supply chain to adopt systems and processes that allow for complete product traceability by 2023. This push for increased transparency in the pharmaceutical industry also includes clinical trial data: A 2018 report revealed that **only 51% of clinical trials reported results.**<sup>4</sup> Amid growing requests to proactively share more clinical trial data<sup>5</sup>, in 2018 the FDA introduced fines for those who failed to report trial information.

The second trend in the pharmaceutical industry before the COVID-19 outbreak was increasing R&D spending and outsourcing of operations as an attempt to mitigate costs. Before the pandemic, global R&D spending **increased at a constant rate, going from \$160 billion in 2016 to \$190 billion in 2019.**<sup>6</sup> To reduce these costs, pharmaceutical companies started to outsource significant parts of their R&D process to clinical organizations, with **40% of the R&D process on average being outsourced** in 2019.<sup>7</sup>

**Exhibit 4: The pharmaceutical industry’s R&D spending is trending upwards, as is its share of outsourced expenditures.**



<sup>3</sup> [2018 Edelman Trust Barometer](#)

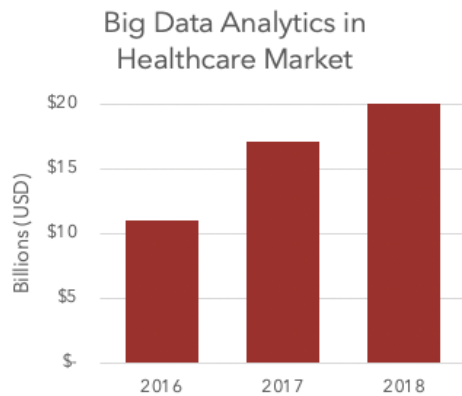
<sup>4</sup> [The BMJ](#)

<sup>5</sup> [The Yale Journal of Law, Medicine, and Ethics, 2017](#)

<sup>6</sup> [Evaluate](#)

<sup>7</sup> [HK Exnews](#)

**Exhibit 5: Spending increases in big data healthcare analytics.**



The last pre-pandemic trend in the pharmaceutical industry was the increased adoption of digitization and big data throughout the entire supply chain. The pharmaceutical industry had been in the midst of gradually starting to understand the competitive advantage offered by increased digitization: according to a 2018 survey, **97% of life science executives agreed that implementing digital technology in the supply chain would improve customer experience.**<sup>8</sup> Before the pandemic, pharmaceutical companies were also experimenting with blockchain and the Internet of Things, which allow for increased product tracing, transparency, and security. In fact, blockchain’s shared ledger infrastructure shows potential to streamline the

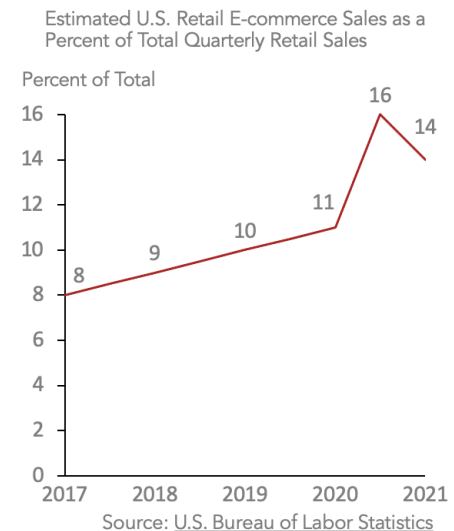
workflow across all supply chain players, from manufacturers and suppliers all the way to distributors and customers. Prior to the COVID-19 outbreak, pharmaceutical companies were also starting to adopt big data in clinical research, with big data **analytics services growing from 11 billion USD in 2016,<sup>9</sup> to 20 billion USD in 2018.<sup>10</sup>**

**4.2 Consumer Retail**

Even before the pandemic, there was already a shift to e-commerce within the consumer retail industry. According to U.S. Department of Commerce estimates, **e-commerce grew by nearly \$80 billion in 2019 to reach a total of \$598 billion, nearly a 16% increase from \$520 billion in 2018.<sup>11</sup> With more shoppers online, e-commerce in 2019 accounted for 15.82% of all U.S. sales.<sup>12</sup>** According to Justin Leigh, Amazon’s CEO, “Online shopping would’ve increased even without the pandemic. During the pandemic, online shopping soared, which also added to the strain.”

Specifically, the apparel industry highlights the complexity of the consumer retail industry’s supply chain. The supply chain starts with new designs, which are then manufactured through acquiring fibers, textiles and finished garments from all over the world. Then, the product is shipped via a wide distribution network transportation logistics to

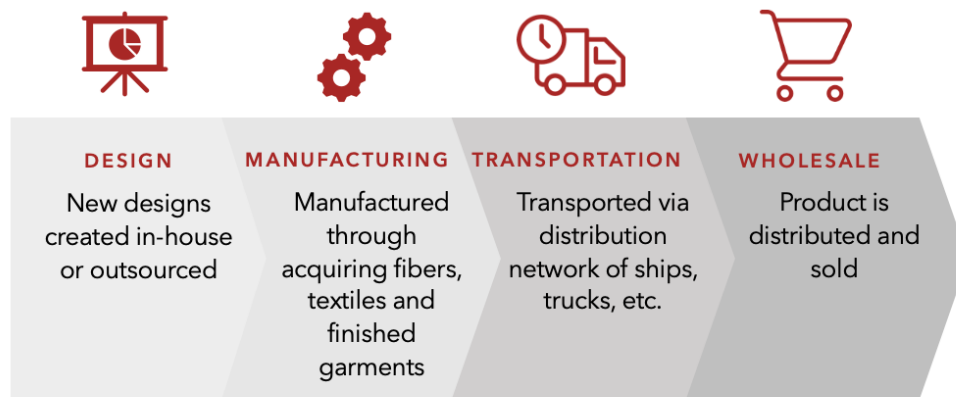
**Exhibit 6: The share of e-commerce spending has steadily increased until recently.**



<sup>8</sup> [Accenture](#)  
<sup>9</sup> [BIS Research](#)  
<sup>10</sup> [Research and Markets](#)  
<sup>11</sup> [Census Bureau](#)  
<sup>12</sup> [Digital Commerce](#)

wholesalers and retailers, where the product is distributed and sold. As a whole, the typical fashion corporation has anywhere between 1,000 to 2,000 suppliers, with numbers reaching 20,000 to 50,000 when including sub-suppliers. With the increased demand for complete supply chain visibility, these **companies must find a way to monitor and manage their complex supplier networks.**<sup>13</sup>

**Exhibit 7: The supply chain for the consumer retail industry is complex and involves several key steps, from design to distribution.**



The consumer retail industry heavily **relies on the twin ports of Los Angeles and Long Beach, which together constitute the ninth largest container port in the world and largest port in America.** Accounting for almost 40% of the country's imported goods, they are the most critical entry points for consumer goods to reach Americans. A combined 7,820 acres of land, 150 cranes, and nearly 50 terminals, the twin ports handle **over 3,600 vessels and 17 million containers each year.** However, while on the surface the twin ports seemed highly efficient, they experience underlying congestion and logistical challenges, problems that COVID-19 brought to light.

### 4.3 Technology

Complex supply chains have become common in the consumer electronics industry due to the wide breadth of specialized production needed.<sup>14</sup> The process begins with the design of the electronic device. Raw materials, such as metals and metal ores, are then extracted to produce the basic components of electronic devices. The next steps in the supply chain involve transforming raw materials into usable components of the final product. The manufacturing process is a highly international operation involving several tiers of production for each component involved in the final assembly of devices. For example, tech companies rely on various manufacturers specializing in producing components such as circuit boards, microchips, speakers, liquid crystal displays, and batteries, all of which require their own intricate supply

<sup>13</sup> [PurolatorInternational](#)

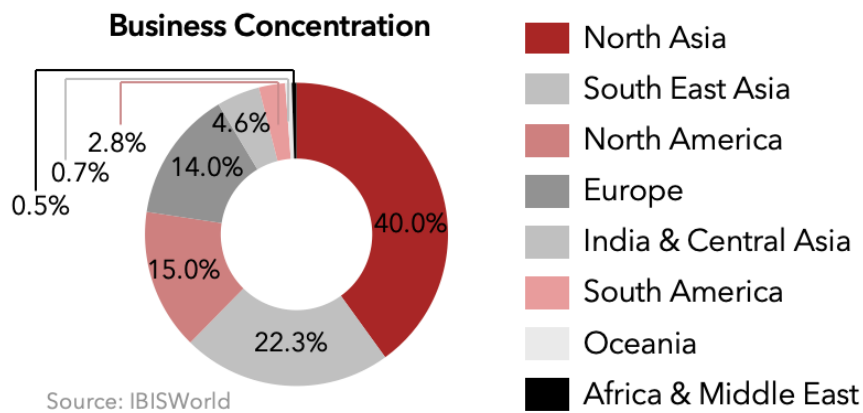
<sup>14</sup> [HBR](#)



chain because of the specialization required for producing electronic parts. Once components have been sourced, the final product is assembled.<sup>15</sup>

Tech companies have outsourced a significant portion of manufacturing capacity in North Asia, mainly China, due to the region's high concentration of established suppliers, qualified and skilled labor, and specialized production capacities.<sup>16</sup> By 2019, for example, China produced **90.6% and 68% of the global supply of PCs and smartphones**, respectively.<sup>17</sup> A more specific example of China's significance in the industry is highlighted by Apple sourcing 46% of its suppliers from the country.<sup>18</sup>

**Exhibit 8: Consumer electronics manufacturing business is concentrated in North and Southeast Asia.**



However, even before the pandemic, the electronics supply chain faced a major disruption due to the U.S.-China trade war. By January 2020, **average U.S. tariffs on Chinese exports were 21%, affecting about 66.4% of Chinese exports** and, based on 2020 import levels, impacting over \$400 billion in goods.<sup>19</sup> Companies began looking to source elsewhere to avoid the costly tariffs, especially in Southeast Asian countries such as Vietnam and Malaysia. Yet, as Harvard Business School Professor Willy Shih, an expert in manufacturing and product development, explains **reducing dependency on China is particularly difficult for the electronics industry, which requires sophisticated production infrastructure and high volumes of labor.**<sup>20</sup> The logistics of shifting production from China to Southeast Asia are costly and time-intensive, realistically taking at least three to five years.<sup>21</sup> This is a significant downside for the industry because of the high expectation to annually produce new devices and component parts, so shifting production could very easily disrupt product development plans if not managed correctly. Furthermore, although

<sup>15</sup> [Ethical Consumer](#)

<sup>16</sup> [Nature](#)

<sup>17</sup> [CKGSB Knowledge](#)

<sup>18</sup> [Apple](#)

<sup>19</sup> [PIIE, American Action Forum](#)

<sup>20</sup> Interview with HBS Professor Willy Shih

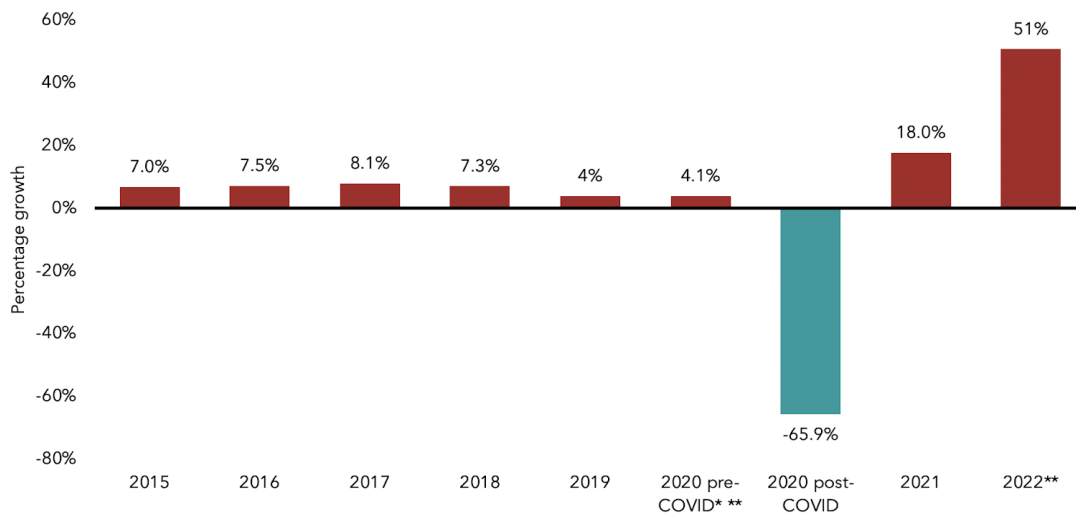
<sup>21</sup> [CNBC](#)

manufacturing is cost-efficient, increased supply chain pressures on Southeast Asia following the trade war highlighted the region’s inefficient ports and transportation system.<sup>22</sup>

#### 4.4 Aerospace & Defense

Prior to the COVID-19 crisis, major aerospace and defense companies like Airbus, Boeing, Raytheon, and Lockheed Martin heavily **relied upon revenue from commercial aircraft orders**. For example, between 2014 and 2019, Airbus fulfilled an average of 1230 gross orders per year.<sup>23</sup> Revenue streams from commercial aircraft orders were relatively stable, with yearly commercial aircraft order demand typically only fluctuating by 100-200 gross orders in any given year. **Annual increases in commercial aircraft orders were fueled in part by consistent increases in passengers for airline travel**; the average annual growth of passenger demand was 6.6% between 2014 and 2019.<sup>24</sup> However, as seen below, COVID-19 caused a dramatic decline in the demand for commercial aircraft, deviating strongly from the pre-pandemic trend.

**Exhibit 9: Growth year-over-year for the aviation industry was relatively steady, then dropped significantly due to COVID-19 in 2020.**



Additionally, defense contractors saw a rapid increase in the demand for defense contracts. In 2019, the **United States secured major arms deals with countries like Taiwan, Saudi Arabia, and Japan to produce arms like precision guided munitions (PGMs), F-35s, and F-16s**. Arms sales occur when an international customer submits a letter of request to the U.S. government. After the arms sale is reviewed and accepted, the Department of Defense lays out items approved for delivery, as well as the raw materials required and the price. Then, approved military contractors like General Dynamics, Raytheon, and Lockheed Martin fulfill the order by manufacturing the

<sup>22</sup> [HBR](#)

<sup>23</sup> [Statista](#)

<sup>24</sup> [Statista](#)

requested items. Given the international nature of projects like the F-35 – which require parts be sourced from NATO partner nations like Australia, Canada, Denmark, Italy, Norway, and (formerly) Turkey – stability of global supply chains was a necessity.<sup>25</sup> Furthermore, arms packages to specific countries continued to grow. The United States approved the sale of missiles, artillery, sensors, F-16s, and other defense systems to Taiwan in 2019, totaling approximately \$4.97 billion.<sup>26</sup> Similarly, there was an \$8.1 billion sale of PGMs and other weaponry to Saudi Arabia in 2019, one of the largest sales in the US-Saudi Arabia relationship.<sup>27</sup> Data from the Stockholm International Peace Institute (SIPRI) indicates that **arms sales revenue totaled \$361 billion in 2019.**<sup>28</sup>

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<sup>25</sup> [Defense News](#)

<sup>26</sup> [VOA News](#)

<sup>27</sup> [Defense News](#)

<sup>28</sup> [SIPRI](#)

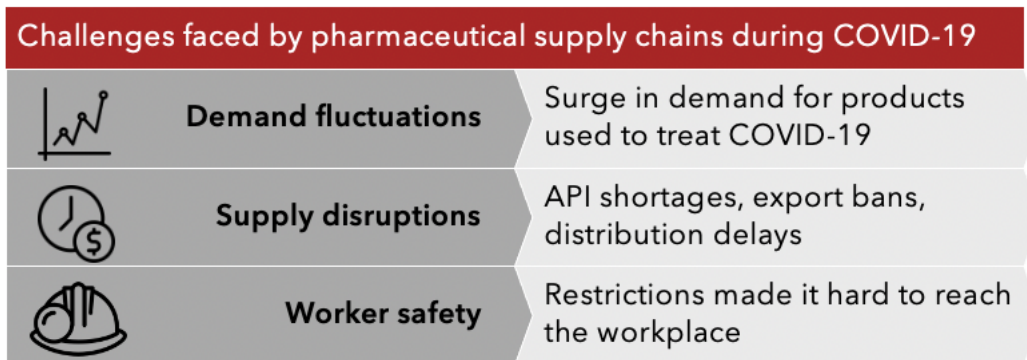
## 5. COVID Impact



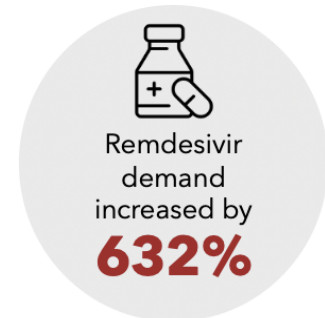
### 5.1 Healthcare

During the COVID-19 outbreak, healthcare and pharmaceutical supply chains faced three key challenges: **demand fluctuations, supply disruptions, and worker safety concerns.**

**Exhibit 10: External public health and supply chain delays, coupled with COVID-19 demands, placed significant strain on the healthcare system.**



The first challenge was dealing with demand fluctuations. Changes in demand varied across pharmaceutical products. There was an extreme surge in demand for products that were actively used to treat COVID-19: **Remdesivir, for example, experienced a 632% spike in demand between July and August 2021,<sup>29</sup> and there were 480,000+ unanticipated prescription fills of hydroxychloroquine and chloroquine between February 16<sup>th</sup> and April 25<sup>th</sup> in 2020, compared with the same period of 2019.<sup>30</sup>** To deal with this unforeseen change in demand, the role played by distributors shifted: they started to promote **increased inventory visibility and limited product hoarding through product allocation programs**, allowing for equal product distribution. On the other hand, pharmaceutical products that were not directly associated with the treatment of COVID-19 did not experience the same surge. For example, top-selling anti-inflammatory drug Humira's revenues continued to increase linearly, as they have over the past ten years.<sup>31</sup>



The second challenge was trying to mitigate supply disruptions. These were mainly due to two factors: export limitations and logistical complications. India's export ban on 26 critical Active Pharmaceutical Ingredients (APIs) in March 2020 shook global supply chains, given that India and China produce 80% of the world's APIs, and there were significant logistical complications due to delays at major ports and a **42% decrease in freight capacity** in the March to April 2020

<sup>29</sup> [Pharmacy Times](#)

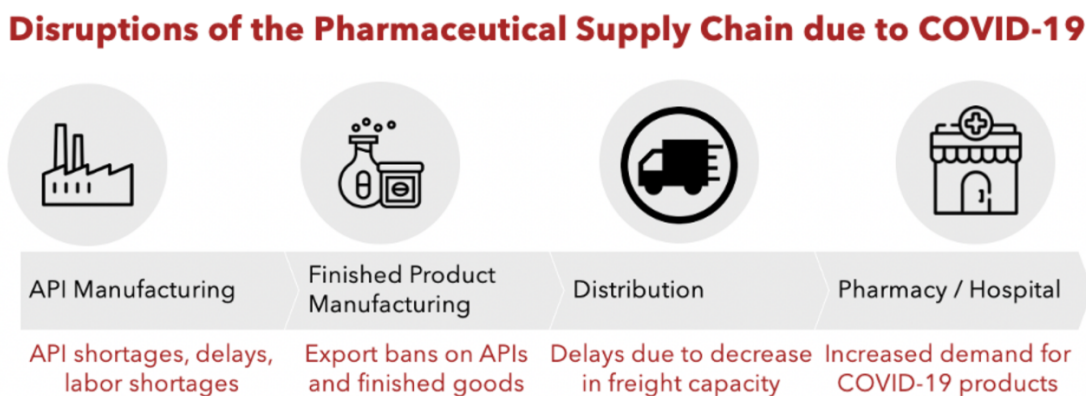
<sup>30</sup> [Jama Network](#)

<sup>31</sup> [AbbVie](#)

time frame.<sup>32</sup> Moreover, as a result of the pandemic, intermediaries (such as distributors) increased prices; for example, a survey conducted by the Association for Accessible Medicines (AAM) revealed that **product transportation costs increased on average by 224% between March and April 2020.**<sup>33</sup>

Healthcare companies also had to deal with maintaining operations while keeping workers safe and adhering to national safety regulations. Supply chains suffered delays from safety regulations such as social distancing and temperature checks, which were necessary to comply with Good Manufacturing Practices (GMP), required by pharmaceutical manufacturers to conform to regulatory agency guidelines. **Stringent lockdowns and public transportation restrictions made it difficult for workers to reach manufacturing plants,** causing product shortages and delays.<sup>34</sup> One example is the case of India, the world’s supplier of over 50% of vaccines globally.<sup>35</sup> When India’s Prime Minister Modi announced the strict national lockdown on March 24, 2020, pharmaceutical companies panicked: not only was it impossible for their workers, who relied on public transport, to get to the manufacturing plant, but the road lockdowns also halted the shipment of ancillary goods required for medicine production,<sup>36</sup> with raw material availability decreasing by 50%.<sup>37</sup> These raw material shortages, partially caused by the fact that the national lockdown meant that workers couldn’t reach the manufacturing plant, caused imported API prices to dramatically increase,<sup>38</sup> and throughout the lockdown period Indian pharmaceutical **manufacturing plants were only operating at 50% capacity.**<sup>39</sup>

**Exhibit 11: This flowchart illustrates the pharmaceutical supply chain along with the disruptions experienced at each step of the way.**



### 5.1.1 Case Study: Pfizer

<sup>32</sup> [IATA](#)

<sup>33</sup> [Accessible Meds](#)

<sup>34</sup> [Economic Times, India](#)

<sup>35</sup> [India Brand Equity Foundation](#)

<sup>36</sup> [Economic Times, India](#)

<sup>37</sup> [Federation of Indian Chambers of Commerce & Industry](#)

<sup>38</sup> [Center for Global Development](#)

<sup>39</sup> [The Print](#)

Pfizer reported a **100% increase in demand for the API Dexamethasone** due to its efficacy in treating patients with severe COVID-19 complications.<sup>40</sup> Moreover, the primary components present in Pfizer’s mRNA COVID vaccines are lipid nanoparticles, yet existing manufacturing plants were insufficient to meet demand. **To deal with lipid nanoparticle shortages, Pfizer diversified its raw material sources.** In addition to expanding its own domestic manufacturing capabilities, the pharmaceutical giant started to buy lipids from other companies, such as British chemical company Croda,<sup>41</sup> Alabama-based Croda subsidiary Avanti Polar Lipids,<sup>42</sup> and German companies Evonik and Merck KGaA. Pfizer’s supply chain was also impeded in 2020 because of delays in importing raw materials, leading the company to **cut its initial vaccine projection of 100 million doses by the end of 2020 to only 50 million.**<sup>43</sup> Moreover, during the pandemic governments and public health entities played a much more prominent role in the pharmaceutical supply chain, financially backing efforts to develop the COVID-19 in an unprecedented manner. In July 2020 Pfizer received a \$1.95 billion advance-purchase agreement from the US Government’s Operation Warp Speed, the program initiated by the US government to accelerate the development of the COVID-19 vaccine.<sup>44</sup>

## 5.2 Consumer Retail

Companies across the retail and consumer sector have faced supply chain challenges from the pandemic, which has **disrupted the flow of goods from manufacturers and suppliers to retailers and consumers.** As the world started recovering from the pandemic, consumers returned to their old purchasing habits, increasing the burden on a supply chain system that was still recovering. The pandemic reversed certain trends and dramatically accelerated others, such as limited labor access, factory shutdowns, and port bottlenecks.

One of the biggest challenges created by COVID-19 lockdowns was the lack of employee supply in the consumer retail industry. According to the U.S. Bureau of Labor Statistics, while 210,000 jobs were added to the U.S. workforce in November of last year, over 20,000 jobs were lost in the retail sector from October. In October 2021, 683,000 retail workers quit their jobs, an increase of 33% from the same time last year.<sup>45</sup> The decline can be attributed to not only health concerns over the lack of

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There was a host of new money coming in [during the pandemic] and many people – particularly people on the modest income level – found that **they could make more money by staying at home and not working than by working.**

- Juan Figueuro, Former VP of Mergers & Acquisitions at Walmart

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<sup>40</sup> [Pfizer Centre One](#)

<sup>41</sup> [CHEManager](#)

<sup>42</sup> [OFI International](#)

<sup>43</sup> [BioPharm International](#)

<sup>44</sup> [New York Times](#)

<sup>45</sup> [U.S. Bureau of Labor Statistics](#)

mask mandates in retail stores, but also from **extended unemployment benefits, SNAP benefits, and stimulus payments.**<sup>46</sup>

However, the recovery within the retail industry has been highly uneven. For example, from November 2019 to the same month in 2021, while non-store retailers had an 11.1% increase in jobs overall, department stores had a job loss of 4.7%.<sup>47</sup> U.S. retailer manufacturing in Asia is freezing up due to a resurgence of variants of COVID-19 in countries such as Vietnam and Indonesia that have become popular



**Exhibit 12: Retail employment decreased drastically in the first months of the pandemic and has yet to make a consistent recovery.**

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“Manufacturing plants stopped due to coronavirus spreading throughout factories, and the country lacked vaccines to prevent the virus.”

- Jason Li, Amazon Vendor

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manufacturing locations for retail companies in recent year. When these countries went into government lockdown, manufacturers in the country were unable to finish producing goods and meet surging customer demands. It has been estimated that **one out of every two manufacturing companies was not prepared for the supply chain disruption due to being reliant upon third party manufacturers and suppliers in Asia.**<sup>48</sup> Matthew Friend, Nike’s Chief Financial Officer, reports of the impact of Vietnam’s lockdown, **“Nike owned inventory**

**declined 7%, with double-digit declines in closeout inventory.** In-transit full-price inventory remains elevated as we continue to experience longer end-to-end lead times for supply. **We expect supply chain delays and higher logistics costs to persist throughout much of FY 2022.**<sup>49</sup>

<sup>46</sup> [Yahoo](#)

<sup>47</sup> [U.S. Bureau of Labor Statistics](#)

<sup>48</sup> [CEC](#)

<sup>49</sup> [MarketWatch](#)

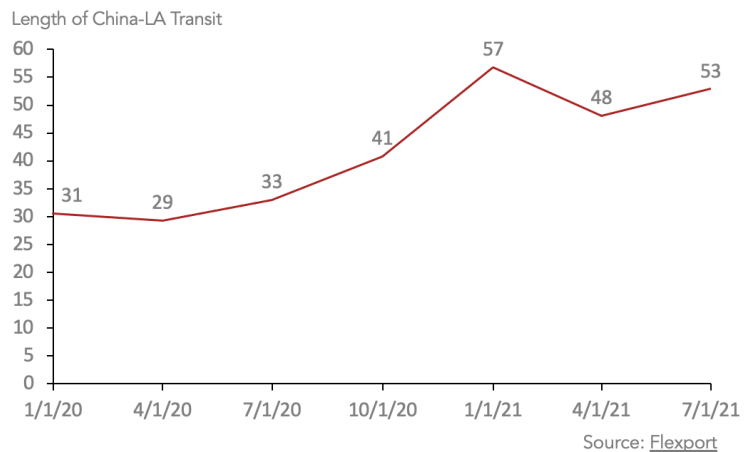
Furthermore, the logistical challenges at the twin ports of Los Angeles & Long Beach continue to accelerate. While there were underlying problems pre-pandemic, it was generally unusual for more than one ship to be in the waiting lane. Now, the ports are a major bottleneck for U.S. retailers, with more than 60

container ships stuck outside the Los Angeles and Long Beach terminals, waiting to unload, due to increased demand for imports, lack of truck drivers and warehouse workers, and pandemic workplace restrictions.<sup>50</sup> According to the Marine Exchange of Southern California, each ship carries thousands of containers of clothing, furniture and electronics, collectively worth billions of dollars.<sup>51</sup> According to data reported by Bloomberg,

ships making the two-to-three-week voyage across the Pacific are forced to spend around that same amount of time waiting in line at the ports before they're allowed to dock and discharge. **The time it takes for goods originating in Shanghai to reach their destinations through the San Pedro Bay ports has more than doubled** (from 30 days to 62 days) since January 2020, meaning further delays in transportation to distribution centers and higher prices for consumers.<sup>52</sup>

Meanwhile, **it now costs \$10,000 to \$15,000 to ship each 40-foot container from China to the West Coast, more than five times the pre-pandemic rate.**<sup>53</sup> Furthermore, the shortage of truck drivers creates problem in shipping out the containers across America and to other parts of the world such as Europe. In fact, the **American Trucking Association estimates that the industry is currently short approximately 80,000 truckers.**<sup>54</sup> However, the Biden Administration has implemented short term strategies to break supply chain logjams by rerouting ships and expanding trucker hours. Walmart Chief Executive Doug McMillon sent a report to the White House on November 29<sup>th</sup>, 2021 stating, "Because of what you all did to help with overnight hours, and because of the team's work to reroute to other ports, to extend our lead times, and have other creative solutions, we have seen an increase in throughput over the last four weeks of about 26% nationally in terms of getting containers through ports."<sup>55</sup>

**Exhibit 13: The transit time to ship goods from ports in China to Los Angeles has increased from 30 to 62 days during the pandemic.**



<sup>50</sup> [NationalReview](#)

<sup>51</sup> [Reuters](#)

<sup>52</sup> [Bloomberg](#)

<sup>53</sup> [Bloomberg](#)

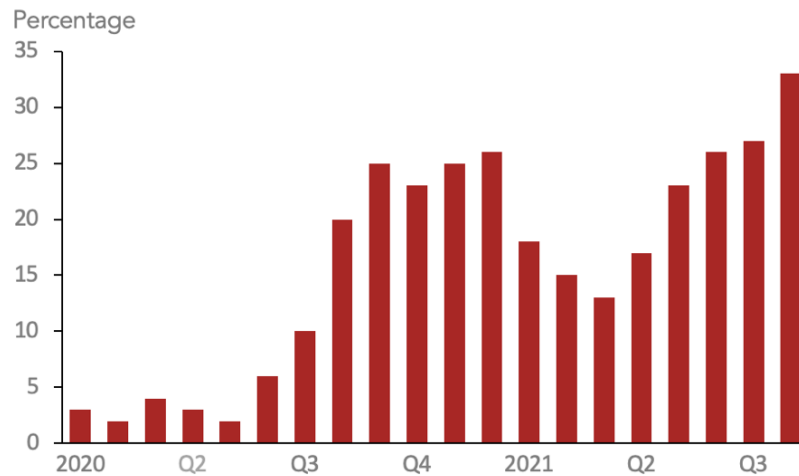
<sup>54</sup> [American Trucking Association](#)

<sup>55</sup> [Reuters](#)



**Exhibit 14: The share of containers waiting >5 days at the docks has increased drastically throughout 2020 and 2021.**

Share of Containers Waiting 5 Days or More at Docks



Source: [Pacific Merchant Shipping Association](#)

**5.2.1 Case Study: Walmart**

One example that exhibits how to react to the aforementioned trends is Walmart, which needed to build up inventory to stay ahead of the inflated costs and supply-chain hurdles at the ports, especially during the critical holiday season. According to a SupplyPike report analyzing data from more than 200 Walmart suppliers throughout 2020, at the start of the pandemic Walmart saw its **in-stock levels for the top nine departments dip below 85% while some Walmart stores remained out-of-stock for weeks**. Furthermore, the report reviewed 53 Walmart category departments, and found that 11 of the critical departments of typically fast-turning departments were below 85% in-stocks by May. By August, out-of-stocks were among the highest of the year in most departments, mainly due to jams at the twin ports of Los Angeles & Long Beach.<sup>56</sup>

Walmart aimed to bypass log-jammed ports and secure scarce ship space. According to Joe Metzger, Walmart’s executive Vice President of Supply Chain Operations, “Walmart has chartered ships and diverted shipments through less congested ports, rerouted inland shipments to avoid rail delays, hired more than 3,000 drivers, and added storage capacity in our fulfillment and distribution network through new facilities.”<sup>57</sup> As a result, Walmart experienced a **51% improvement in supply chain flow through the ports in Southern California, and inventory increased by 20% from the previous year**.<sup>58</sup>

<sup>56</sup> [SupplyPike](#)

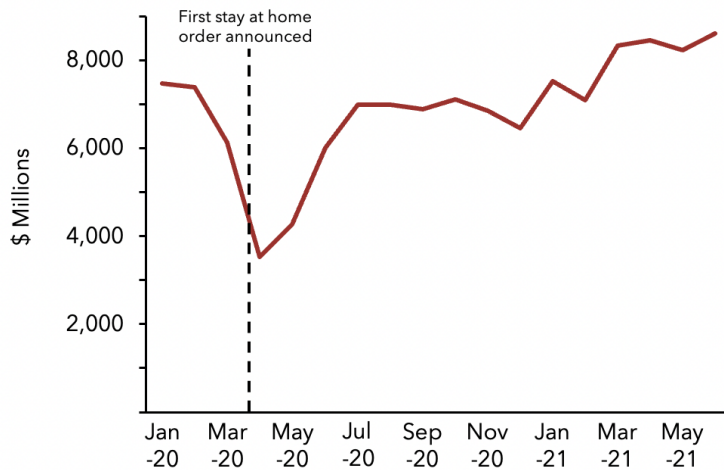
<sup>57</sup> [Walmart](#)

<sup>58</sup> [Washington Post](#)

### 5.3 Technology

Following the emergence of COVID-19, China swiftly mandated factory shutdowns throughout the country to mitigate the spread of the virus. Additional preventative actions in other countries also led to many manufacturing facilities outside of China shutting down or greatly reducing operations. Production of electronic components and finished products were essentially halted following global regulations and enforcement, further exacerbating supply chain disruptions already present because of the U.S.-China trade war.

**Exhibit 15: Monthly retail sales of electronic stores in the U.S. increased dramatically at the onset of the pandemic.**



Source: Statista

Tech companies further witnessed a surge in consumer demand in developed countries following the supply shock.<sup>59</sup> In the U.S., **66% of workers and 93% of U.S. households with school-age children experienced some form of remote work or learning, leading to higher demand for PCs, audio, and visual electronic products** while factories were still shut down.<sup>60,61</sup> Spare leisure time due to quarantines also contributed to increased demand for electronic products such, as game consoles and TVs, in high-income countries.

The combination of supply shocks and increased demand during the COVID-19 pandemic put a strain on the electronics industry's supply chain, causing shortages in consumer electronics. These **shortages have delayed shipments and increased backlogs, uncertainty, and manufacturing costs, generating further pressures** on the supply chain. Results from a survey conducted by the IPC, a trade association aiming to standardize the production of electronics, corroborated these effects on the electronics supply chain.<sup>62</sup>

<sup>59</sup> [IBISWorld](#)

<sup>60</sup> [Statista](#)

<sup>61</sup> [U.S. Census Bureau](#)

<sup>62</sup> [IPC](#)

The combination of supply shocks due to lockdowns and increased demand for work from home technology put a strain on the electronics industry's supply chain, causing shortages in consumer electronics. These **shortages have delayed shipments and increased backlogs, uncertainty, and manufacturing costs, generating further pressures** on the supply chain. Results from a survey conducted by the IPC, a trade association aiming to standardize the production of electronics, corroborated these effects on the electronics supply chain.

**Exhibit 16: Shortages in the semiconductor industry will likely be long-lasting, causing higher costs, shortages, and delays in production for a majority of suppliers.**



Although the availability of most categories of goods have gradually begun recovering in the U.S., stockouts have continued to be persistent in the consumer electronics industry. This accumulated to near record-high levels in May 2021 as **electronics stockouts remained 40% higher than pre-pandemic levels**.<sup>63</sup>

Sony has particularly suffered from product stockouts, as the company's PS5 continues to be in shortage into 2022.<sup>64</sup> The company's leadership has expressed concerns about the current state of the product's supply chain and Sony cut its original production plans for the console.<sup>65</sup> Part of the explanation was the **sudden surge in demand for electronic entertainment during lockdowns**. However, the low supply of PS5s highlights the shortage of another product causing major disruption in the electronics supply chain – semiconductor microchips.

Semiconductor chips are found in virtually all consumer electronics, such as computers, smartphones, gaming devices, medical equipment, and navigation systems, with the chips designed to conduct electricity in devices. These chips experienced the same changes in supply and demand as the general electronics industry; however, **the shortage of chips has been a notable disruptor of the electronics supply chain because of its importance across all product**

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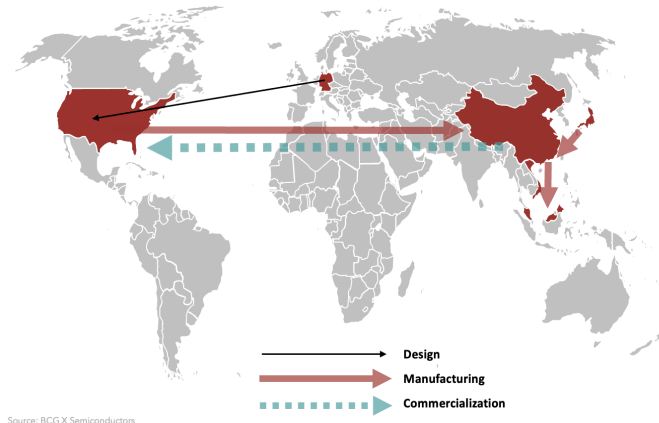
<sup>63</sup> [NBER](#)

<sup>64</sup> [Bloomberg](#)

<sup>65</sup> [IGN](#)

**types in the technology industry.** Another key area where semiconductor chips are crucial is in the automotive industry, which was also extremely hard hit by this shortage.

**Exhibit 17: This is an example global journey of semiconductor, from design to manufacturing to commercialization.**



### 5.3.1 Automotive Industry Case Study

Leading up to 2019, the automotive industry was defined by tariffs on steel and aluminum, chip shortages, and declining consumer demand. **Before COVID-19, sales within the automotive industry were already projected to decline by 7%-10% in 2020.**<sup>66</sup> Globally, automakers sold 2.4 million vehicles in 2019 – a 3.1% decrease compared to the year earlier.<sup>67</sup>

Since COVID-19 exacerbated the semiconductor shortage, major companies like Tesla, GM, and Sony all suffered from reduced output in 2020. For the first time since 2017, the period between when a chip order was placed and then filled reached 15 weeks. Popular **suppliers like Broadcom have seen order fulfillment times increase from 12.2 weeks to 22.2 weeks.**<sup>68</sup> The shortage is due in part to a rapid increase in demand for cars as more people preferred the option of driving on their own during the pandemic, as well as for electronic goods like smartphones and PCs to work from home, making it nearly impossible for prominent chip manufacturers to produce at appropriate levels to meet demand.

The **consensus among experts is that the supply of semiconductor chips will still be “tight” during the first half of 2022**, thus affecting the production of electronic devices. The CEO of AMD, an American manufacturer of semiconductors, has offered an optimistic prediction where the chip shortage will have concluded by the second half of 2022.<sup>69</sup> Deloitte, on the other hand, has predicted wait times of 10 to 20 weeks for chips by the end of 2022.<sup>70</sup>

<sup>66</sup> [Global Supply Chain Blog](#)

<sup>67</sup> [CNBC](#)

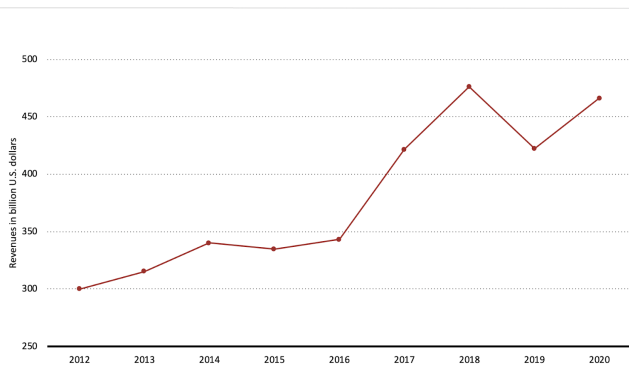
<sup>68</sup> [CNBC](#)

<sup>69</sup> [CNBC](#)

<sup>70</sup> [Deloitte](#)

Due to COVID-induced shutdowns, **automobile manufacturers have been forced to suspend manufacturing throughout the world.** For instance, Ford suspended manufacturing in the US, Nissan suspended manufacturing in the UK, and Toyota and BMW suspended manufacturing throughout Europe. Meanwhile, Honda shut down 4 plants throughout Southeast Asia, and Volkswagen suspended all manufacturing.<sup>71</sup> Since **car manufacturers source a large portion of their parts from Southeast Asia – where COVID protocols are especially strict** – outbreaks have hit manufacturers especially hard.<sup>72</sup> Combined with the chip shortage, shutdowns throughout South Asia are predicted to **cost the entirety of the automobile industry approximately \$210 billion in lost sales.**<sup>73</sup> Companies like Nissan have confirmed losses, stating that production output fell 22% in October 2021 compared to October 2020. Similarly, Honda also confirmed that production output declined by 28% – a shrinkage for the fifth consecutive month in a row.<sup>74</sup>

**Exhibit 18: Semiconductor industry revenue worldwide, 2012 - 2020, has increased rapidly in recent years.**



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#### 5.4 Aerospace & Defense

While aerospace companies could historically rely upon commercial aircraft orders, COVID-19 caused a dramatic decline in the demand for commercial aircraft. In August 2020, there was a 59% decline on commercial aircraft orders compared to the number of orders in the same month the previous year. Similarly, **there was a 91.3% decline on commercial aircraft orders in August 2020 compared to the number of orders in in the same month two years ago.**<sup>75</sup>



**decline in orders from 2019 to 2020, during the onset of the pandemic.**

<sup>71</sup> [Global Risk Insights](#)

<sup>72</sup> [Asia Nikkei](#)

<sup>73</sup> [CNBC](#)

<sup>74</sup> [Bloomberg](#)

<sup>75</sup> [Reuters](#)

In 2020, approximately 55% of aircraft deliveries were canceled,<sup>76</sup> leaving aerospace manufacturers struggling with large amounts of debt and minimal amounts of demand. Additionally, passenger demand took its largest hit in decades during the pandemic, with a 65.9% shrinkage during 2020.<sup>77</sup> Since passenger demand is directly correlated with manufacturing orders, COVID will directly impact manufacturers within the aviation industry. pandemic. **Going forward, aerospace analysts expect orders for major corporations within the aviation industry like Boeing and Airbus to decrease by up to 50%.**<sup>78</sup>

Experts such as Chris Caplice, the executive director of the MIT Center for Transportation & Logistics, **expect demand within the commercial aircraft industry to return to normalcy by late 2023.** Additionally, due to efforts to mitigate the spread of COVID-19 on flights and among workers, the air cargo industry is dramatically reducing its air freight capacity and canceling flights across the board. Conversely, the global arms industry is relatively insulated from the impact of COVID-19. **Although the IMF projected a decrease in arms sales by 3.1%, there was an overall increase of arms sales by 1.3% in 2020.**<sup>79</sup> Thus, major defense and aerospace companies like **Lockheed Martin have pivoted away from aviation contracts and invested more resources in fulfilling defense contracts.**

#### 5.4.1 Raytheon Case Study

Raytheon confirms a general trend in the defense and aerospace industry. In 2020, Raytheon had to lay off approximately 20,000 workers due to the COVID pandemic.<sup>80</sup> Supply lines shut down rapidly, as the **close proximity of workers in production facilities presented a large COVID risk.** This resulted in a **34% loss of sales for Raytheon in the third quarter of 2020.**<sup>81</sup> While COVID hit defense companies especially hard towards the onset of the pandemic, suppliers recovered by moving away from aviation to instead invest more resources into defense and arms contracts. **Demand for arms rapidly increased in 2021, with Raytheon receiving some of the largest production contracts in its history—** the Navy paid \$269,034,300 for the modification of the Evolved Seasparrow Missile, while the Air Force paid \$2 billion for nuclear cruise missile production.<sup>82</sup> Thus, contractors like Raytheon are offsetting disruptions to their respective supply chains by increasing their volume of arms contracts.

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<sup>76</sup> [Oliver Wyman](#)

<sup>77</sup> [Statista](#)

<sup>78</sup> [Umlaut](#)

<sup>79</sup> [SIPRI](#)

<sup>80</sup> [Reuters](#)

<sup>81</sup> [Raytheon](#)

<sup>82</sup> [Defense Department](#)

## 6. Future Trends



### 6.1 Geographic Diversification

Future Trend	Implementation	Challenge Addressed
Supply Diversification	Sourcing from multiple suppliers and geographies	Supply shortages and reliance on few suppliers and regions

The pandemic highlighted the **dangers associated with excessive reliance on a few suppliers or on a specific geography for raw materials**. While it is more cost-effective to rely on a single supply source, it makes the supply chain much **more vulnerable to disruption**. For instance, in the healthcare industry, the disruptions caused in March 2020 by India’s export restrictions on 26 critical APIs, which accounted for 10% of India’s pharmaceutical exports<sup>83</sup> and included generic products such as paracetamol, demonstrated how dangerous it is to rely on a single region for raw materials. Considering that **India and China collectively produce 80% of the world’s APIs**, this temporary export ban delayed drug production and aggravated supply shortages worldwide.

As a result, numerous large companies are leaving China in droves. A Gartner survey of supply chain leaders showed that **33% of companies have plans to move at least a portion of their manufacturing out of China by 2023**.<sup>84</sup> Even pre-COVID, tariffs from the U.S.-China trade war and issues with intellectual property theft have pushed companies to look elsewhere to scale manufacturing quickly and affordably.<sup>85</sup> When COVID-19 hit, China’s rigid “zero-COVID” policies that severely limited travel into the country, shutdowns from the Omicron and Delta variants, and **rapidly shifting regulations on private corporations drove up costs and forced major companies to move manufacturing to countries closer to the U.S., Southeast Asia, and East Europe**.<sup>86</sup> According to data from Panjiva, nearly half (49%) of Nike’s imports are from Vietnam, as the company has started shifting their manufacturing to Southeast Asian countries in hopes of diversifying their supply chain away from dependence on China.<sup>87</sup>

However, this is not the case for all companies: While the biggest companies have the resources to move subcontracting out of China to domestic production, most **small and mid-sized companies don’t have the manufacturing expertise or the budget to build facilities**. In many cases, these smaller companies subcontracted manufacturing to China in the first place because it required less startup capital, which allowed them to compete in the market.<sup>88</sup> In fact, a survey released by the American Chamber Commerce found that of 338 small company leaders who

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<sup>83</sup> [Reuters](#)

<sup>84</sup> [Gartner](#)

<sup>85</sup> [National Law Review](#)

<sup>86</sup> [Forbes](#)

<sup>87</sup> [Marketplace](#)

<sup>88</sup> [Time](#)

responded, over **70% said they had no plans to move their supply chains out of China in the next three years.**<sup>89</sup>

Moreover, **diversifying supply bases will be especially difficult for consumer electronics.**

Although several tech companies, such as Apple and Sony, have been moving production out of China and into Southeast Asia, the **industry's supply chain is still primarily based in China due to the country's deep supplier network.** The convoluted nature of electronics manufacturing can result in a supply chain that is up to nine tiers of suppliers deep, with most tech companies not being aware of suppliers past the second tier of component production.<sup>90</sup>

Interestingly, there are very few manufacturing centers for components that are deeper in the electronics supply chain, with a large amount of production centering around China because of **the country's well established production facilities, high volumes of low-cost labor, access to raw materials, and transportation infrastructure.**<sup>91</sup> China's strong presence deep into the supply chain makes it unlikely for the industry to completely cut the country out of its supply chain anytime soon.

“ Only China has the **ability to supply the high-volume of labor needed** to sufficiently produce for initial stocking orders.

-Willy C. Shih, HBS Professor ”

The electronics industry's difficulty in reducing dependency on China has now caused the **widespread emergence of the “China plus one” strategy. This involves spreading production between China and a Southeast Asian country, such as Vietnam.** While these “plus one” countries still heavily depend on China for raw materials and transportation infrastructure, they provide firms with lower costs of production at different stages of the value chain. For example, Vietnam has become popular among consumer electronics producers specifically for product assembly and testing due to the low cost of labor. However, most experts agree the country still does not have the infrastructure needed for larger scale manufacturing.<sup>92</sup>

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<sup>89</sup> [American Chamber of Commerce](#)

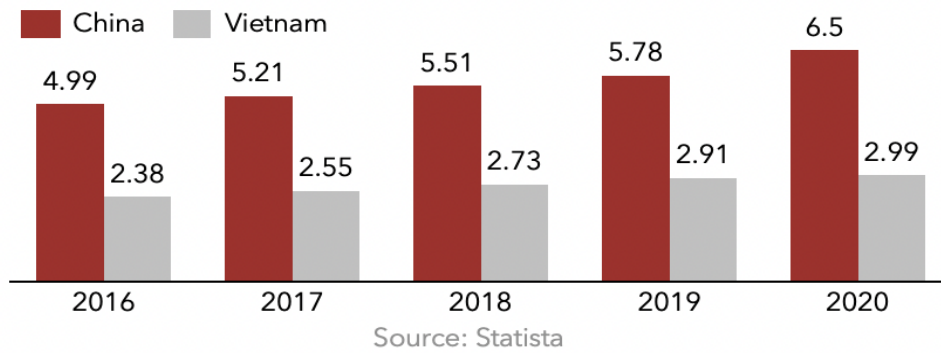
<sup>90</sup> Interview with HBS Professor Willy Shih.

<sup>91</sup> [Exponent](#)

<sup>92</sup> [Exponent](#)



**Exhibit 20: Manufacturing labor costs per hour are much higher for China than Vietnam.**



An additional way we see diversification is **a resurgence in domestic manufacturing to reduce reliance on third-party raw material hubs, move manufacturing in-house, and increase supply chain flexibility.** Pharmaceutical giants Pfizer, Moderna, and AstraZeneca have already started investing in their domestic manufacturing facilities to gradually move some of their outsourced manufacturing in-house, and it's safe to anticipate that other companies will increasingly follow their lead. Supply diversification, investment in domestic manufacturing hubs, and getting regulatory approval, however, are not changes that can be implemented immediately. They require complete shifts in the way traditional supply chains operate, as well as notable capital investment. However, **if this transition were to begin today, we would most likely start seeing supply diversification progress by 2023,** according to Professor Prashant Yadav - a globally recognized scholar in the field of healthcare supply chains.<sup>93</sup>

Indeed, as a result of the semiconductor microchip shortage, governments, including the U.S., the European Union, and China, have begun pushing to increase domestic supplies of the product. In the U.S., the Biden administration passed the CHIPS Act: a \$52 billion plan to provide subsidies for the R&D and manufacturing of microchips. As a result, companies such as Intel and Samsung have already begun producing manufacturing plants in the country.<sup>94</sup> However, in this case and many similar ones, **this is an extremely inefficient move with an estimated total upfront investment of \$900 billion-1.225 trillion for the semiconductor chip industry,** compared to its profit of \$242 billion in 2021.<sup>95,96</sup>

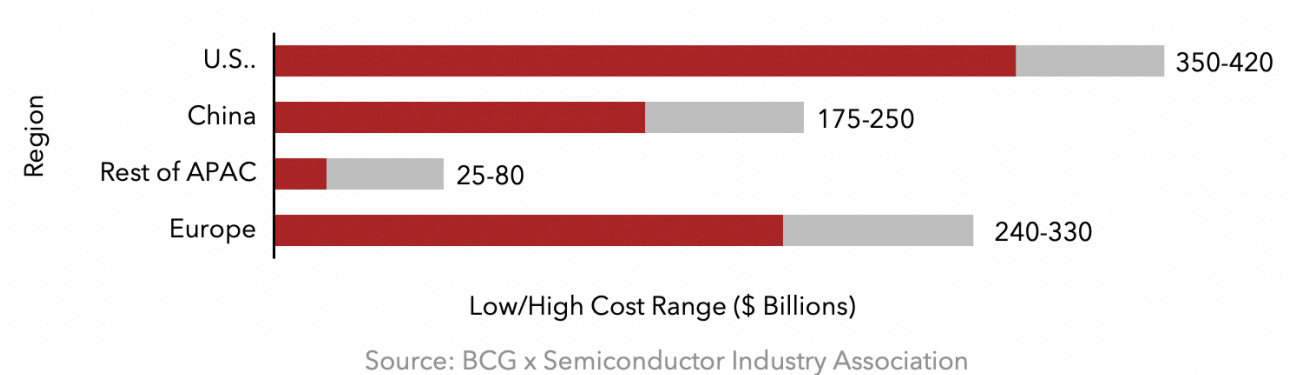
<sup>93</sup> Interview with Yadav Prashant.

<sup>94</sup> [The New York Times](#)

<sup>95</sup> [Semiconductor Industry Association](#)

<sup>96</sup> [IBISWorld](#)

**Exhibit 21: The upfront investment to satisfy the demand for semiconductors in 2019 by localizing the supply chain is quite significant.**



Recent trends in the consumer electronics industry calls for more resilient supply chains located outside of China. However, this puts supply chains in danger of losing economies of scale already well-established in the country. **The rise in production costs from supply base diversification is likely to be passed onto consumers, at least in part, in the form of higher prices for their products.** Localizing areas of the supply chain would generally involve higher costs for companies and be very time-consuming, thus making **outsourcing to Southeast Asia the most likely long-term diversification strategy.**

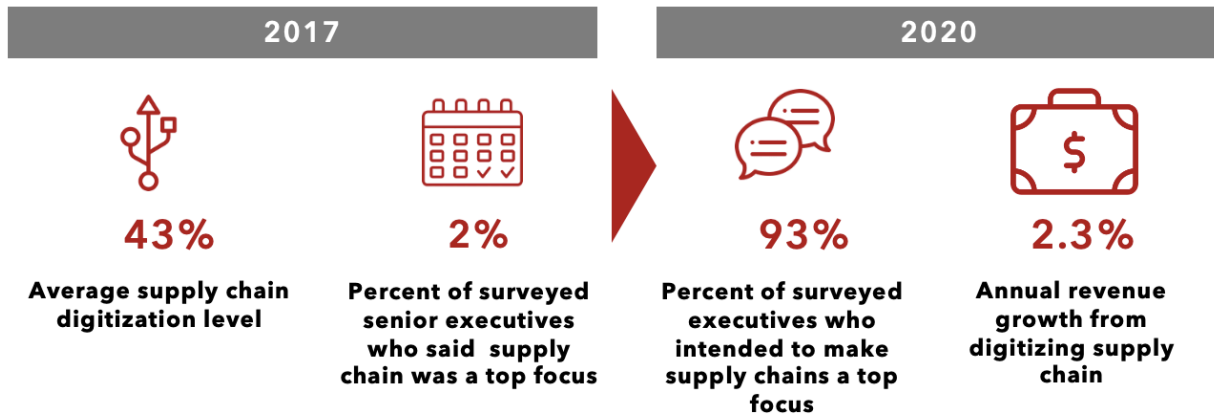
## 6.2 Digitization & Automation

Future Trend	Implementation	Challenge Addressed
Digitization	Adopting blockchain and IoT in pharma supply chains	Increasing costs, operational inefficiencies, stock waste, limited product traceability

Another future trend that has emerged after the pharmaceutical industry’s response to the COVID-19 outbreak is increased investment in digitization. In 2017, a McKinsey study found that the average supply chain has a digitization level of 43%, and only 2% of the surveyed executives claimed that the supply chain was a top focus of the company’s digital strategies.<sup>97</sup> In 2020, a new McKinsey study found that up to 93% of senior executives intended to make their supply chains far more flexible, agile, and resilient. The research suggests that **companies that digitize their supply chains can expect to boost annual growth of earnings by an average of 3.2% and annual revenue growth by an average of 2.3%.**<sup>98</sup>

<sup>97</sup> [McKinsey](#)  
<sup>98</sup> [McKinsey](#)

**Exhibit 22: Increasing supply chain digitization has become a top priority among executives following the pandemic.**



The pandemic highlighted the benefits and resilience of digitized supply chains that rely on blockchain technology and the Internet of Things (IoT). There are three clear benefits related to supply chain digitization: **improved efficiency, more sustainable sourcing, and cost management.**<sup>99</sup>

First, adopting blockchain technology allows for **greater communication and transparency between all supply chain parties, effectively boosting operational efficiency.** Blockchain allows for increased tracking functionality, which is critical when faced with regulations such as the 2013 Drug Supply Chain Security Act that requires pharmaceutical companies to be able to trace their products and keep records of their movements. IoT then allows for sensors placed on machinery throughout the supply chain to collect data like temperature and GPS location and automatically upload this data to a cloud server. Moreover, using blockchain and IoT technology also allows for more efficiently automated data-driven decision-making based on real time data and actionable insights.

**Benefits of Supply Chain Digitization**

- 1
 Operational Efficiency
- 2
 Sustainable Sourcing
- 3
 Cost Management

Research company Prologis found that **greater digitization in warehouses helps increase facility and distribution productivity by 10% to 20%.** With warehouse operations and real-time inventory tracking among the biggest supply chain challenges retailers face, the automations were able to improve order accuracy, speed up order processing time, manage space usage, and synchronize workforce tasks. Co-op, a major UK grocer, used in-store, cloud-based fulfillment solutions to fulfill online orders in less than two hours from click to delivery.

<sup>99</sup> [Forbes](#)

Another example is the MediLedger Network, a working group of pharmaceutical manufacturers launched in 2017.<sup>100</sup> The group is exploring how blockchain technology can help with drug traceability and authentication to meet the requirements of the Drug Supply Chain Security Act by 2023. MediLedger Network's goal is to understand how to verify the authenticity of drug identifiers throughout the supply chain without proprietary data being openly shared on the blockchain to reduce pharmaceutical counterfeits.<sup>101</sup> The outbreak of the pandemic revealed the importance of fast decision making and digitizing the supply chain allows for the necessary faster adaptability.

However, digitization not only increases supply chain efficiency, but also allows for more ethical and sustainable sourcing. **Increased product traceability allows companies to verify exactly where the products they are sourcing come from, their authenticity, and how they were manufactured.** In the pharmaceutical industry, adoption of blockchain technology used for API tracking throughout the manufacturing process shows potential to be able to address drug counterfeit operations. In fact, by tracking drugs from the manufacturing plant all the way to end consumers, blockchain technology demonstrates potential to not only mitigate the \$200 billion yearly losses, but also to prevent an estimated one million deaths per year from counterfeit medicine.<sup>102</sup>

The last clear benefit of digitizing supply chains is cost management. With better traceability comes greater savings, as blockchain integration reduces stock loss, waste, and dependence on paper-based materials. In fact, **the electronics industry is forecasted to cut \$62 billion in costs through digitization** – one of the highest reductions out of all industries surveyed. These benefits have led the industry to plan around \$243 billion in investing in digitized supply chains over the next five years.<sup>103</sup>

While companies are already starting to adopt these digital technologies, realistically, considering the multitude of regulatory restrictions and privacy concerns that pharmaceutical supply chain digitization entails, it will take at least three to five years for the industry to implement these technologies and fully embrace its potential benefits.<sup>104</sup>

## 6.3 Industry-Specific Restructuring

### 6.3.1 Healthcare

The pandemic highlighted a critical weakness in the way traditional pharmaceutical supply chains operate, which is the very limited interface between the supply chain and national governments. **Dealing with such a large-scale health issue revealed the importance of having a**

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<sup>100</sup> [MediLedger](#)

<sup>101</sup> [Reuters](#)

<sup>102</sup> [Nasdaq](#)

<sup>103</sup> [PWC](#)

<sup>104</sup> Interview with Yadav Prashant.

**stable liaison with government health officials**, which therefore makes it safe to assume that companies will increasingly start exploring what this role could look like and how to best support public health efforts.<sup>105</sup>

Secondly, to effectively diversify preexisting supply chains, it's likely that **VPs of sourcing will have increasingly active roles in the pharmaceutical industry, opting for multiple different suppliers located in various geographies** instead of the traditional leading pharmaceutical distributors such as Cardinal or McKesson.

Finally, it's reasonable to anticipate **hospital group purchasing organizations (GPOs) to play a much more active role in ensuring pharmaceutical supply**, offering an alternative to traditional supply chains. One example of this trend is Civica RX, a drug manufacturer launched in 2018 to combat drug shortages and increasing prices for generic pharmaceuticals.<sup>106</sup> Civica RX members pay a one-time-fee to be a part of the group and then negotiate individual contracts for each drug.

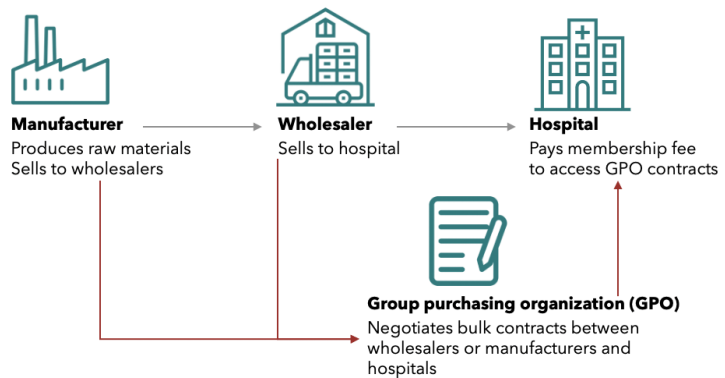
These last for five, seven or ten years, and hospitals commit to purchasing at least half of their drug volume through Civica. **These long-term contracts help eliminate pharmaceutical volume uncertainty and, therefore, will help combat shortages and stabilize prices because volume and price are built into the contracts.**

These trends will dramatically change the traditional pharmaceutical supply chain, prioritizing diversified supply sources, drug availability and price stability. While some of these structural shifts might be quicker to implement, these changes require executives to fundamentally reimagine their supply chains and will likely take until at least 2025 to implement.

### 6.3.2 Consumer Retail

**Companies have continued to transform former retail stores into mini-fulfillment centers as online shopping continues to skyrocket.** In 2019, global industrial real estate firm CBRE noted major retailers were choosing to convert under-performing retail properties into packaging, transportation, and logistic hubs.

**Exhibit 23: Manufacturers and wholesalers can now operate through GPO intermediaries to deliver products to hospitals more reliably.**



<sup>105</sup> Interview with Yadav Prashant.

<sup>106</sup> [SP Global](#)

During COVID, with many retailers unable to open stores for long periods amid lockdowns, more retailers started **transforming under-performing retail properties into fulfillment centers to provide an economical way to build out the distribution network while moving inventory closer to capitalize on demand for shorter delivery times.**<sup>107</sup> Indeed, a PwC consumer survey found 88% of shoppers are willing to pay extra for same-day or faster delivery.<sup>108</sup> Around the nation, empty stores and shopping centers were repurposed for distribution while physical shops served as warehouses and fulfillment centers. For example, Target acknowledged that 95% of the company's fourth-quarter sales were fulfilled by its stores-turned-warehouses.<sup>109</sup>

However, this model needs accurate and reliable inventory tracking, **the use of RFID tracking has helped provide real-time information on the availability of inventory.** For example, Lululemon's accurate inventory tracking powered by RFID technology allowed quick shipment of items to customers from the nearest store location where the item was available. This tactic is likely to grow as stores continue to close and bricks-and-mortar demand gradually recovers.

### 6.3.3 Technology

The shortages caused by the COVID-19 pandemic have resulted in electronics manufacturers rethinking well-established supply chain organizations. A major restructuring has been in the industry's use of lean manufacturing strategies. These strategies had previously involved reducing costs by minimizing the amount of inventory held by a given company's global supply chain. Following the beginning of semiconductor shortages, **tech companies began countering the traditional lean practices common in the industry; instead of continuing just-in-time practices and holding minimal inventory, the electronics industry began a widespread stockpiling of chips** to prevent further disruptions in individual supply chains. Following this response, it became more common for companies to begin building higher levels of safety inventories for essential components of production.<sup>110</sup>

**Holding excess inventory has the potential to prevent higher material costs and revenue loss attributed to product shortages.** The pandemic has resulted in tech companies generally seeking to minimize risks by being more strategic in the way they gather component parts.

### 6.3.4 Aerospace & Defense

After the demand shocks induced by COVID-19, suppliers cannot solely rely upon revenue streams from the aviation industry. **Aerospace companies have diversified their supply chain structure to supply manufactured parts, raw materials, and weaponry to the defense industry,** as defense spending has not shrunk throughout the pandemic.

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<sup>107</sup> [CBRE](#)

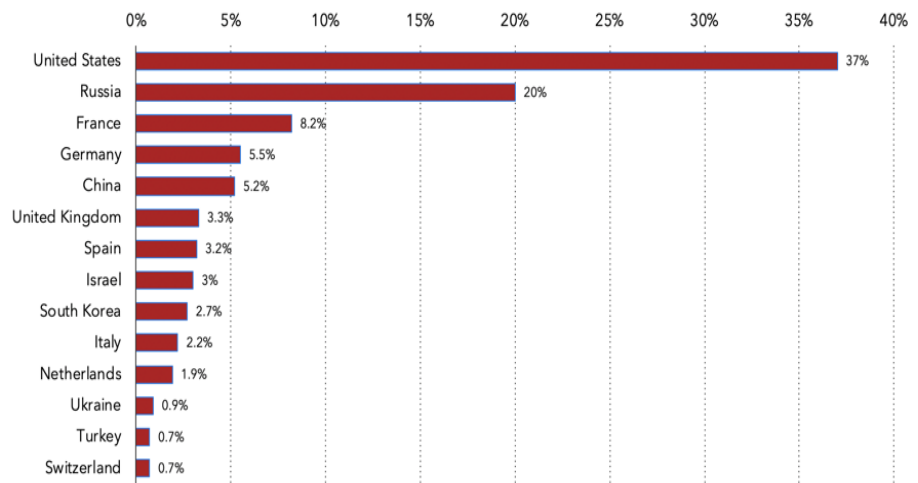
<sup>108</sup> [PwC](#)

<sup>109</sup> [NPR](#)

<sup>110</sup> [&Marketing](#)

The military is building relationships with commercial and industry suppliers. **Thus, major defense and aerospace companies like Lockheed Martin have pivoted away from aviation contracts and invested more resources in fulfilling defense contracts.** Lockheed Martin alone sold \$58 billion in weapons in 2020, while companies like Raytheon received historically large contracts, like a \$2 billion contract for producing nuclear cruise missiles.<sup>111</sup> Comparatively, aviation companies cut down on production since the costs of raw materials increased between 27% and 44% in 2021 compared to 2020.<sup>112</sup> The combination of decreased demand for aviation goods and increased cost of production has applied extraordinary amounts of pressure on suppliers to pivot towards the defense industry.

**Exhibit 24: U.S. has the predominant market share of arms exports compared to other countries.**



Source(s): Statista

Indeed, the U.S. arms market continues to flourish. Between 2015 and 2019, Stockholm International Peace Research Institute data indicates that the United States is responsible for 37% of all arms exports, with Russia, the second largest exporter, responsible for only 20%.<sup>113</sup> This figure increased by 2% during COVID, indicating that the share of the arms market controlled by the United States has remained relatively stable.

Structurally, it is unlikely that suppliers like Russia and China will overtake the United States in future decades. Russia continues to struggle with rejection from prominent international institutions like NATO - a roadblock to production of crucial military aircraft like the F-35. Since China does not have the capabilities to produce weapons in-house, it is deeply reliant on imported arms, meaning the U.S. will remain the only supplier of weapons to international allies. In the future, experts predict that the U.S. will continue to increase its dominant market share in the Middle East, as exports grew at a 25% rate between 2016 and 2020.<sup>114</sup> Thus, **the arms industry will be a very lucrative opportunity for domestic manufacturers due to the US's absolute advantage in demand, production, and supply of arms.**

<sup>111</sup> [Raytheon](#)

<sup>112</sup> [Reuters](#)

<sup>113</sup> [Defense News](#)

<sup>114</sup> [BBC](#)

## 7. Conclusion

The COVID-19 pandemic disrupted industries on a global scale, exposing vulnerabilities in the traditional supply chain model and forcing executives to shift strategies. In examining the impact of the COVID-19 outbreak on supply chains in the retail, consumer goods, pharmaceutical and technology industries, insights can be derived from the main challenges that these industries faced as a result of the pandemic. **Excessive reliance on single suppliers and geographies combined with unpredictable demand for COVID-related products created a mismatch between supply and demand, with distribution disruptions and national export bans worsening the disruptions.**

To address these challenges, **companies were forced to implement three major shifts that will inform future supply chain trends: diversification, digitization, and supply chain restructuring.**

One of the major learnings from the pandemic is the imminent threat posed by dependence on single supply sources. To address this vulnerability, **companies are already starting to source from multiple suppliers in diverse geographies**, helping increase supply chain diversification and resilience.

Moreover, the pandemic highlighted the need for **faster decision making, improved operational efficiency, and cost management, which companies are starting to achieve by adopting increased digitization** as well as reliance on blockchain and the Internet of Things. The increased product traceability and authentication enabled by supply chain digitization will also help businesses manage costs, significantly reducing stock waste, and source more sustainably, as companies can verify exactly where their supply comes from.

Finally, **the pandemic exposed the need for general supply chain restructuring** to improve businesses' risk management and resilience to disruptions, and **each industry is starting to reimagine its supply chain in a slightly different way**. While all these industries are experiencing slightly different pandemic-related challenges, diversification, digitization, and supply chain restructuring will be the predominant trends in delineating what the future of supply chains will look like, and the most successful companies navigating supply chain adaptations over the course of the next five years will have innovated across these three avenues.





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Originally from New Jersey, Esteban Medina is a first-year student studying Applied Math & Economics. Esteban serves as an editor for the Harvard Economics Review and debates on the Harvard Model UN team. In his free time, he enjoys exploring art museums and trying out new restaurants.



### **Sofia Cagliero**

Sofia Cagliero is a first-year student from Milan, Italy, studying Applied Mathematics & Economics with a secondary in Computer Science. Outside of HCCG, she's also Director of Communications for Harvard Ventures, and in her free time she enjoys trying new foods and exploring Boston.



### **Adarsh Hiremath**

Originally from Sunnyvale, CA, Adarsh Hiremath is a freshman in Wigglesworth studying Applied Mathematics and Computer Science. Outside of HCCG, Adarsh enjoys partaking running, hiking, or playing basketball. Academically, he's interested in economic policy as well as machine learning.



### **Henry Xuan**

Henry Xuan is a freshman currently living in the Prescotts and pursuing a concentration in Economics. He grew up in China but moved back to Atlanta, Georgia where he went to Lambert High School. Beyond HCCG, Henry is a part of Harvard Student Agencies and the Asian American Christian Fellowship.

