

2020: Global Systemic Risk in the Face of COVID-19

Section 3: Supply Chains by Kevin Zheng and Joe DiMarino

COVID-19 creates an immeasurable amount of interruptions in various supply chains across the globe. The effects on agricultural, technological, automotive, energy, and pharmaceutical supply chains are substantial and concerning. After extensive research, particular vulnerabilities rose to the surface that-if fixed-can prevent future susceptibility in similar situations.

Global supply chains have leaders in specific sectors. Regardless of the industry, COVID-19 has severe repercussions for all sectors. The main supply chain giants are Germany, Korea, Italy, Japan, USA, and China (Baldwin). Together, they account for 60% of all manufacturing and 55% of the supply and demand (Baldwin). Interruptions in manufacturing in any of these countries causes a ripple down effect to all parts of the world. This ripple effect is called the “supply chain contagion” (Baldwin). China is the leading manufacturing powerhouse in the world, and its shutdown has significantly impacted the global economy through its “supply chain contagion.” “China is at the heart of such Global Value Chains (GVC’s); China is a primary producer of high-value products and components, a large customer of global commodities and industrial products, and a major consumer marketplace. China also produces many intermediate inputs and is responsible for processing and assembly operations (Managing COVID-19: How the Pandemic Disrupts Global Value Chains).” Global supply chains rely extensively on China, and thus COVID-19 is interfering with the world’s production. “51,000 companies worldwide have one or more direct suppliers in Wuhan, and at least 5 million companies worldwide have one or more tier-two suppliers in the Wuhan region (Ivanov).” Companies are feeling the effect of the supply chain shock; “94% of the Fortune 1000 companies have been reported seeing coronavirus supply chain (SC) disruptions (Ivanov).” “The world’s largest 1,000 SCs own more than 12,000 facilities in COVID-19’s quarantine areas (Ivanov).” This research and analysis aims to find ways to create less of a ripple effect down the supply chain.

Supply chains fragment in a wide variety of situations; a critical aspect to consider is where. “The SC performance reaction depends on the ripple effect’s timing and scale, and when the facility opens and closes at different SC echelons (Ivanov).” The World Trade Organization predicts trade decreasing as much as 32% in 2020 (Fernandes). Most supply chains are built more for efficiency rather than resiliency. This structure is problematic because circumstances show that a resiliency-based model may be more economical in the long-term; “supply chain managers know the risks of single sourcing, but they do it anyway to secure their supply or meet a cost target (*Coronavirus Is Proving We Need More Resilient Supply Chains*).” There is a clear relationship between increasing efficiency and fragility.

The research for this section focuses mainly on pharmaceutical supply chains, specifically generic drug supply chains. Generic drugs account for 90% of the US drug supply and many of the world's drug supply (Tucker). Drug shortages are a constant problem for the world, and COVID-19 has exacerbated this. In 2019, there were 264 drug shortages in the US (Tucker). Most shortages occur with generic drugs because of their tighter margins and focus on efficiency (Tucker). "Supply chains for generic drugs are often lean. Typically each stage holds little inventory, ranging from a few weeks to a few months. The API (active pharmaceutical ingredient) may be made by a single manufacturing plant (Tucker)." The regulations for these manufacturers are also quite lengthy and can interfere with the supply chain's efficiency, causing delays and even shortages. Furthermore, the older the population, the higher the demand for drugs. This observation introduces the relationship between life expectancy and the greater demand for drugs. As healthcare innovations continue to rise, a higher life expectancy could result in significant shortages. Many API suppliers started hoarding their stock due to fear of seizure (Choo). COVID-19 also stresses the healthcare system because many medical professionals have to focus their time and energy to prioritize distribution of limited medications (Gerr, M). After interviewing several doctors, many expressed these frustrations and concerns about inadequate supplies.

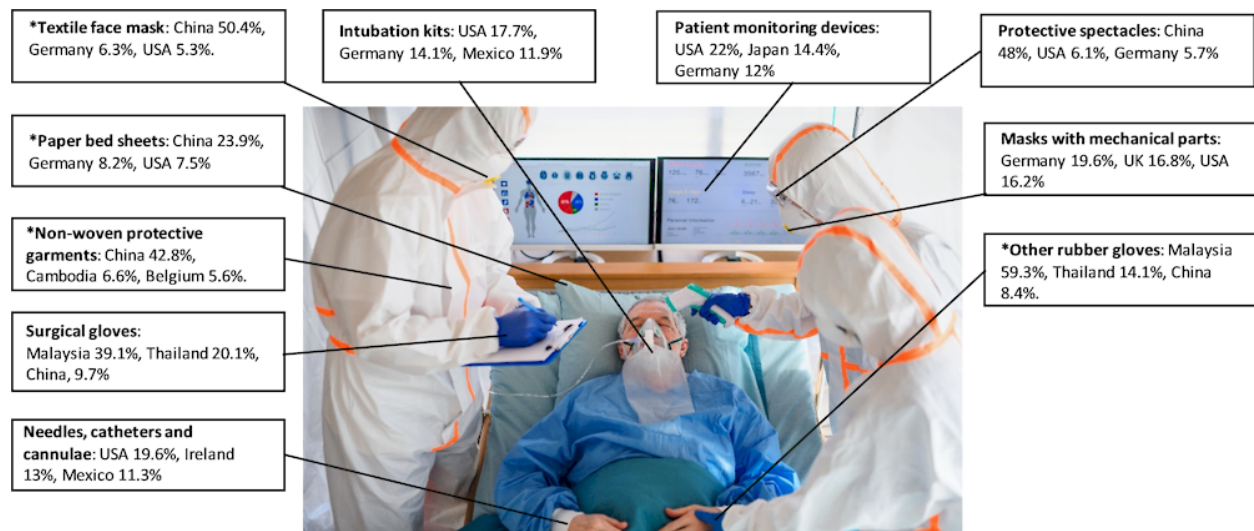
After researching the pandemic's effect on Asia, there have been some severe repercussions for the pharmaceutical supply chain due to China's restrictions. India is a significant player in the industry as well; "80% of chemicals used to make drugs sold in Europe now originate from China and India (Mullin)." There is a strong interdependence among China and India that affects the rest of the world. "In 2018-19, India exported nearly \$19 billion worth of pharmaceuticals to more than 200 countries (Guerin)." "India manufacturers represent 67% of the 563 WHO prequalified pharmaceutical products for a range of conditions (Guerin)." However, they receive around 70% of their APIs from China (Chatterjee). India's trade deficit with China is about \$58.04 billion (India-China Trade and Economic Relations). Although India has cheap labor, their industrial capacity is no match for China. India would hurt itself more if it restricted trade with China. India halted the export of 13 drugs in March as well as hydroxychloroquine on March 25th. It lifted the hydroxychloroquine ban on April 6th (COVID-19: Managing Drug Shortages). This export ban was responsible for cutting around 50% of the US hydroxychloroquine supply (*India Partially Lifts Export Hydroxychloroquine Ban*). Asia's power in the pharmaceutical industry is intense and highly concentrated. From a risk perspective, this is highly problematic when those countries can no longer export drugs due to situations like COVID-19.

Turning to the West, the US has less manufacturing infrastructure than countries like China and India. Two major US generic drug manufacturers are Sandoz Ltd. and Mylan Inc (32541b). The US relies on a large number of imports for its manufacturing. "Imports for the generic pharma manufacturing industry are expected to account for

42.5% of domestic demand in 2020 (32541b, 22).” Speaking of domestic demand, generic drugs are quite popular. “Generics have saved the US healthcare system almost \$2 trillion over the last decade (32541b, 20).” Furthermore, private health insurance increases the amount of access to medical care leading to a higher amount of pharmaceuticals demanded and purchased. The US has a strong demand for generics but lacks the independent infrastructure that could limit its vulnerability.

The increased demand for medical supplies during the COVID-19 pandemic is an effective case study demonstrating the high interconnectivity of not just drugs but also medical supplies at large. While Germany and the United States are the leading exporters of medical electronics, testing kits, and disinfectants, other countries such as China and Malaysia dominate the global production of Personal Protective Equipment (OECD). This leads to high interdependency even among top exports. For example, Germany imports EUR 0.72 of COVID-19 goods for every euro it exports (OECD). In the United States, the US exports USD 0.75 of COVID-19 goods for every dollar it imports (OECD). Countries are recognizing the importance of maintaining incoming international supply chains with most adopting import liberalization measures, such as reducing tariffs and licensing requirements for medical goods. However, this is accompanied by increasing export restrictions. This creates a problematic scenario where established dependencies as countries attempt to secure imports while blocking exports. On a global scale this disrupts trade and can worsen shortages are not specialized to produce goods they previously imported.

Global Export Share for various COVID-19 goods



Inspired from this existing scholarship, we computationally analyzed global trade to perform a data-driven exploration of existing pharmaceutical supply chain trends. We focused on US imports, mining data from the UN ComTrade database. Using Standard International Trade Classification (SITC) 54 (Representing medicinal and pharmaceutical products) and US import data from 2019 we determined that, by value, the largest exporting country was Ireland (31%) followed by Germany (12.9%) and Switzerland (11.8%). Surprisingly, China and India represented significantly, at 2.1% and 5.8% respectively. We attribute this to China and India's lower domestic costs and focus on generic drugs, leading to lower trade value. As well, these top European countries are home to many inverted American corporations which inflates value. For example, Ireland is home to many American firms who are located there due to lower corporate taxes and tariff free access to the European Union. Many American companies based there will then charge higher prices to their American affiliates, so these expenses can be deducted from taxes as business expenses. When we examined volume, however, China (101.9 million Kg) , India (97.8 million Kg), and Mexico (85.4 million Kg) instead were the dominant producers. These countries exported significantly by volume more compared to the top exporters by value, Ireland and Germany exported 12.5 million KG and 32.1 million kg respectively. This research was enlightening because it shows where US dependence lies. This research could be used to generate policy and action towards mitigating risk in these areas.

These findings led us to speculate that high value export countries, such as Ireland and Germany, were likely sourcing their active pharmaceutical ingredients and preparation products from China and India. To investigate this we took a deeper look into the network and examined import data from the top exporters to these countries. We switched to Standard Industrial Classification (SIC) 2834 (Pharmaceutical preparations) to give us increased granularity. Contrary to our expectations, we found that most countries, when filtering by volume, sourced their pharmaceutical inputs from nearby countries. For example, the top exporting countries for Germany were France (27.2%) and Spain (10.87%) and for Ireland, the UK (42.9%) and Germany (13.1%). For India and China the top exporters were the Philippines (34.5%) and Hong Kong (29.4%), respectively. These results suggest regional complexity in pharmaceutical supply chains; a disruption in the Philippines may have impacts on drug shortages in America due to its connection to Indian drug exports. Consistent with the previous scholarship we discussed, our research demonstrates a complex and interconnected global pharmaceutical supply chain which is vulnerable to foreign disruptions.

After diving into extensive research on the topic, it was interesting to observe similar impediments occurring in the supply chains of illicit drugs. Most manufacturers that do not source their inputs from other countries are struggling less with drug manufacturing than multinational manufacturers (COVID-19 and the drug supply chain). The very end of the illegal drug supply chain seems to be where a majority of the

problems manifest, specifically in destination markets (COVID-19 and the drug supply chain). Drug-Trafficking by land is becoming riskier due to increased regulation, so many are shifting to maritime trafficking. The border control COVID-19 initiatives are making it a lot harder to traffic these drugs. Many suppliers are holding on to their drugs in fear of seizure similar to API suppliers (COVID-19 and the drug supply chain). As a result, manufacturers are stockpiling their supply, this stockpiling could result in far lower drug prices after COVID-19 due to extreme supply. The drop in prices could then result in higher consumption and abuse. Potentially, COVID-19 can stimulate higher drug use and trafficking due to poverty rates climbing from the economic downturn (*Covid-19-and-drug-supply-chain-Mai2020.pdf*). Citizens are out of jobs and may need to resort to trafficking to make a living. This same pattern has been studied from the 08-09 crisis too.

This section has mainly focused on current problems and risks associated with supply chains during COVID-19. However, many scholars and professionals have proposed solutions. From a global supply chain perspective, policies and regulations could be enacted to mitigate risk and the likelihood of extensive ripples in the supply chain. After observing the extreme reliance on China, it may be beneficial to scatter supply chain locations to reduce density and dependence on certain areas. Building and improving national supply chains could also help reduce dependency on other countries (*Managing COVID-19: How the Pandemic Disrupts Global Value Chains*). This resolution helped with the food supply chain when grocers were not able to import all of their products due to a sudden spike in demand (Hobbs); many consumers resorted to local suppliers to meet their needs in a tough situation. It could be useful to find supplemental inputs to allow for more production flexibility (Friend, S). Having reserved supplies, second-string suppliers, “lead time reservations,” and “regional subcontractors” would help create a safety net for many supply chains (Ivanov). This safety net can also be built by fostering collaborative buyer-supplier relationships because suppliers “are more likely to ‘go the extra mile’ (e.g., priority restocking) in times of crisis for a retail buyer (Hobbs, 3).” Many suppliers have a hard time detecting problems quickly. Therefore, an intense and comprehensive supply chain monitoring system would be quite helpful. “The coronavirus epidemic teaches us-once again- that a robust supplier-monitoring system that maps sub-tier dependencies is a basic requirement of today’s supply chain and sourcing professionals (*Coronavirus Is Proving We Need More Resilient Supply Chains*).” The COVID-19 pandemic also illustrates the importance of highlighting the correct industries and jobs as essential to ensure that production never lags (Hobbs). One last aspect from a global perspective is to stress the need for manufacturers to build their supply chain networks with more resiliency. COVID-19 is teaching a lesson to those who try to squeeze out every efficiency possible, leaving no room for problems. In the short term, this may be efficient, but in the long term, it can have serious repercussions.

With generic drugs in particular, several other solutions may be efficacious. Similarly to some global solutions, producing drugs in multiple plants would help spread out risk and reliance on certain generic drug manufacturers. The locations of the supply chains should move closer to the end of the supply chain to reduce susceptibility to problems. Furthermore, each country should strengthen its industrial capacity for producing generic drugs. India (and many other countries) should take the initial hit in costs to bolster its industrial capacity and allow for future sustainability and less reliance on China (Chatterjee). The US has recently made an effort to increase its generic drug manufacturing industry by granting a \$765 million loan to Kodak to produce pharmaceuticals (Reichert, C). Kodak has an extensive infrastructure that can be adapted to provide medicines. Grants could help cover the cost of moving other companies' manufacturing facilities back to the US-and other countries who want to follow (A Blueprint for Enhancing the Security of the US Pharmaceutical Supply Chain). The HHS and BARDA could give grants for US companies. Tax incentives for this approach could also help. The government could discourage investment in cheaper foreign versions of the essential drugs to help stimulate its own growth (A Blueprint for Enhancing the Security of the US Pharmaceutical Supply Chain). A "dual supply chain where 3/4 of the domestic demand is met by domestic production" could provide a lot more flexibility and resilience than relying heavily on other countries (Mirchandani). Many drug manufacturers and suppliers have expressed frustration with the approval process causing delays and even shortages. Limiting the review process, especially during a pandemic, for these drugs would be very helpful for suppliers (**32541b**). However, intense regulation helps protect consumers against faulty drugs or possible poisoning. Once again, an extensive monitoring system would allow for transparency across the whole supply chain and increase the ability to detect and resolve problems. One solution that the European Medicines Agency implemented is called the i-SPOC, which stands for the Industry Single Point of Contact system (HRABOVSKI, G). This system helps pharma companies report any supply chain issues for essential medicines during the pandemic and will allow governments and companies to carefully monitor the current pharma supply chains. This transparency can even catalyze larger brand name drug manufacturers to step in and help cover shortages of essential drugs. To further increase transparency, another solution could include integrating the pharmaceutical, medical device, and healthcare service supply chains. This integration could give more vision and awareness to the industry as well as effectively monitor the SCs (Guerr, M). Some other solutions include creating and maintaining an emergency stockpile (Mirchandani), limiting oversubscribing, virtual manufacturing, and standardizing the treatment of the same illnesses (Guerr, M). Single-use technology can increase productive efficiency by allowing manufacturers to begin a new production process in 15-18 months rather than 3-5 years, thus cutting down lag in the supply chain (*32541b*). There is also a potential for creating medicines on the spot (similar to mixing paint),

which would allow for a more flexible supply chain (Guerr, M). The US Department of Health and Human Services (and many other countries) should create a list of essential medications to help specify and prioritize these medications to mitigate shortages (A Blueprint for Enhancing the Security of the US Pharmaceutical Supply Chain). If certain drugs could be labeled “High Priority,” the US (and many other countries) should produce them within the country to reduce any risk from being cut off in supply. If enacted, many of these potential solutions could help mitigate the risks of generic drug supply chains.

Several Drug Shortages or Supply Issues

Paracetamol	Penicillin	Chloramphenicol	clindamycin	erythromycin	antiretroviral acyclovir
Hydroxychloroquine	Midazolam	Propofol	Fentanyl	Nazalme	Morphine
Midazolam	Sasurium	Vecuronium	Rocuronium	Norepinephrine	Sedatives
Analgesics	Paralytics	Narcotics			

Sources of Error and Next Steps

- The UN Comtrade Data was not as granular as we desired. Since countries may specialize in the production of different types of drugs, the aggregation may obscure some trends. As our qualitative analysis revealed, the United States has many drug shortages yet is a top global exporter of medicaments. Similarly, the aggregation of APIs does not allow us to analyze the API bottlenecks for specific drugs. For example, it is possible that most narcotic APIs are sourced from the same country, something undiscoverable from our macro analysis. In future research, it would be valuable to perform our analysis on a more granular level. Data for that is not readily available and would need to be gathered first hand.
- The nature of UN Comtrade Data only allowed us to perform one degree of analysis for API ingredients. This creates an issue where countries are assumed to be self sufficient despite potentially not having domestically produced all necessary components. In future research, it would be valuable to conduct a few case studies on APIs to track their full production chain allowing for estimation of the number of degrees in API networks.

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